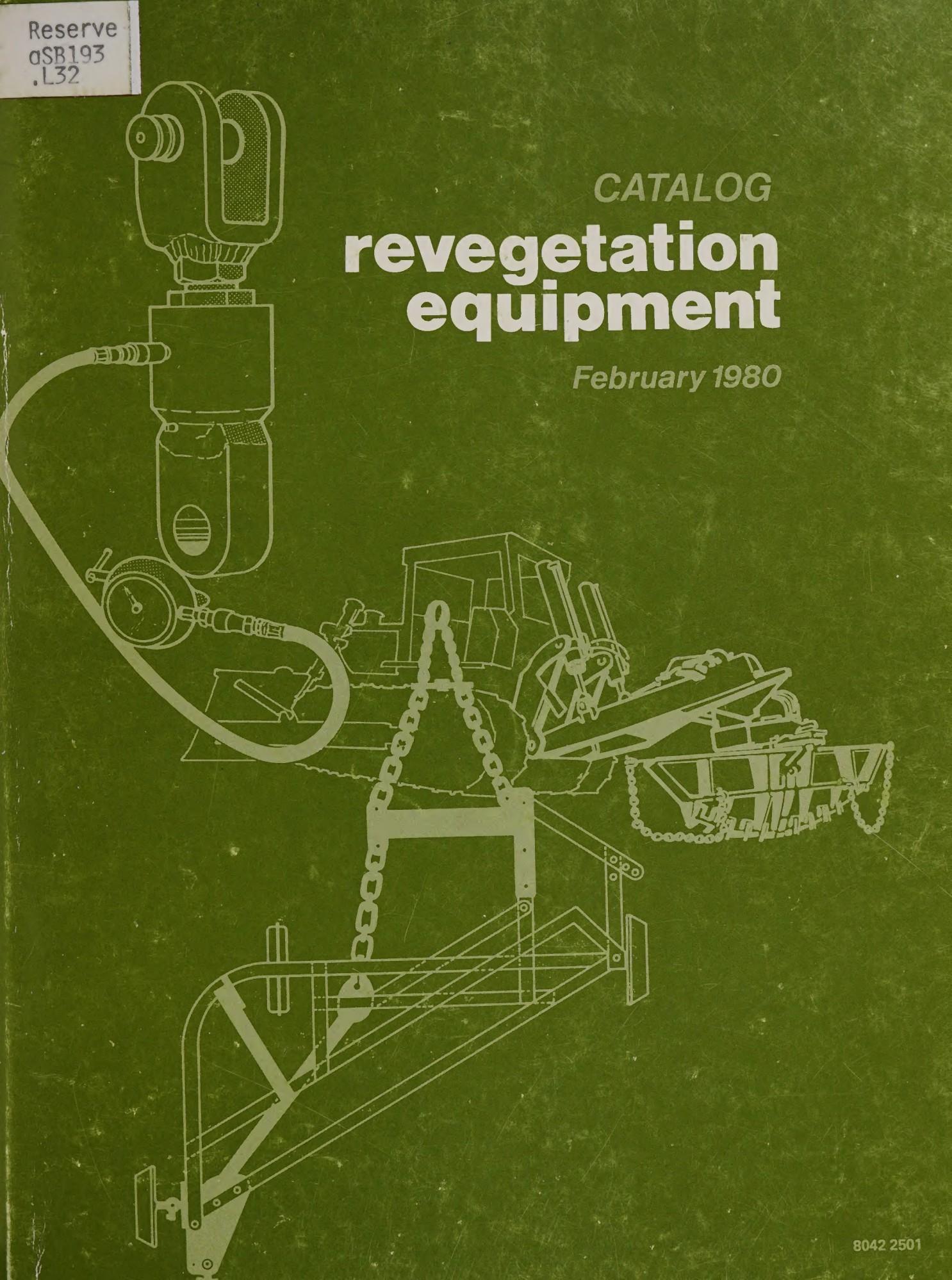


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# CATALOG

## revegetation equipment

February 1980

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REVEGETATION EQUIPMENT  
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Prepared for the

Vegetative Rehabilitation and  
Equipment Workshop  
(VREW)

by

John E. Larson  
Range Technician

February 1980

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The Vegetative Rehabilitation and Equipment Workshop is an organization of Federal and State agencies and private groups working to improve rangelands and further range equipment technology. Government officials and industry and university representatives from other countries also participate. Participants at the 1979 meeting were from U.S. Department of Agriculture, U.S. Department of the Interior, State and County Organizations, State Wildlife Agencies, Industry (Chemical Equipment, Mining, Seed), Educational Institutions, Canada, Morocco, Kuwait, and Mexico.

To accomplish its goals, the Workshop evaluates and develops equipment and prescribes specifications and standards for equipment purchase, maintenance, and use. The Workshop also functions as a clearinghouse for the interchange of information and the dissemination of material describing its activities and accomplishments.

Those interested in participating in the Workshop should contact its chairman, Ted V. Russell, Range Management Staff, USDA Forest Service, P.O. Box 2417, Washington, D.C. 20013.

For information on equipment or techniques, contact the appropriate Workgroup chairman:

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## Introduction

This catalog describes the structure and operation of equipment designed or adapted for range and wildlife habitat improvement and disturbed land rehabilitation. Categories of equipment include: (1) equipment for vegetation management or control, (2) revegetation or seeding equipment, (3) equipment for the preservation of existing vegetative communities, and (4) related or supportive equipment. Many types of equipment have broad applications and serve many purposes. I have attempted to group such equipment according to its primary function.

Most of the equipment in the catalog is commercially manufactured. Implements and machines that are not commercially available usually have both detailed drawings and working prototypes. A few pieces of equipment are included that are still under development.

This catalog is intended as an informative guide to available vegetative rehabilitation equipment. For each type of equipment, I have listed the major manufacturers or sources for information. However, the availability lists, photos, or descriptions that are included do not imply

recommendation or endorsement of specific equipment to the exclusion of similar equipment that may be suitable. Many specifications have been obtained from equipment manufacturers and have not been independently verified.

The catalog may also serve as a planning aid for land treatments or equipment operation. In most cases, information on operating techniques, as well as equipment capabilities and limitations, has been supplied.

When planning treatments and selecting suitable equipment, the objectives of your project should be carefully determined. These objectives should be derived from sound ecological principles and adequate public involvement to ensure optimum allocation of available human and material resources. The management objectives should be clearly defined because they will have a profound influence on the choice of equipment or techniques. This handbook should help land managers make wise and informed choices of equipment suited for specific tasks and, perhaps, help them discover new or improved treatment techniques consistent with available technology.



Tractors are the main prime movers used in range improvement and disturbed land reclamation work. They supply the sustained force necessary to move implements over or through the ground. Tractors also supply power through hydraulic or power-take-off attachments. This power is used to position or operate implements. Tractors can be used on almost any terrain.

Enough power can be obtained for any reasonable range improvement or revegetation application (appendixes A and B). Production rates are partly determined by tractor speed (appendix C), but many implements have speed limitations for optimum production. Excessive power and speed may damage equipment or limit the effectiveness of the operation.

## Rear-Wheel Drive Tractors

### Function

Rubber-tired, rear-wheel drive tractors move light implements on relatively level ground. They are desirable on fragile surfaces that may be damaged by crawler tractors. Implements can be attached to the power-take-off or hydraulic systems.

### Description

Rear-wheel drive tractors are powered by gas or diesel engines. The large rear wheels supply good traction for pulling implements over or through the ground. The tractors are steered with the smaller front wheels. The rubber tires can be filled with a calcium chloride solution or equipped with wheel weights for improved traction. Dual rear wheels will also improve traction. Implements can be powered either hydraulically or by power-take-off (PTO) attachments. Three-point hitches are standard equipment on most rubber-tired tractors. Many rear-wheel drive tractors are also available with optional front wheel drive (appendix A).



*Typical rear-wheel drive tractor.*

### Techniques

Rear-wheel drive tractors are powerful pulling machines. Their engines have good low speed torque or lugging ability. The optional front-wheel drive supplies additional traction. The tractors pull a wide variety of farm implements. Small dozer blades or loader buckets are sometimes mounted on the front of the machines. Weights are often attached to the front of rear-wheel drive tractors to counterbalance their torque.

### Capabilities

Rear-wheel drive tractors can pull farm implements at speeds over 10 mph (16 km/hr), although maximum pulling power is usually obtained at slower speeds. Rear-wheel drive tractors are also very maneuverable.

### Limitations

Rear-wheel drive tractors are limited to fairly flat ground with slopes under 20 percent. Numerous sharp rocks or brush snags may damage tractor tires. Because the weight of rubber-tired tractors is concentrated on a small area of tire tread, these tractors contribute to soil compaction and may destroy soil structure if operated on very wet ground. These agricultural tractors may lack the ability to treat heavy stands of brush.



*All-wheel drive tractor with articulated steering.*

## Specifications

Power ratings (PTO) 20 to 195 hp (15 to 145 kW)  
Maximum pull to 18,500 lb (8,391 kg)  
Speed at maximum pulling power 4 to 10.2 mph  
(6.4 to 16.4 km/hr)

Additional information may be obtained from the Nebraska Tractor Test Laboratory, University of Nebraska, East Campus, Lincoln, Nebr. 68503.

## Availability

Allis Chalmers  
Agricultural Equipment Div.  
Box 512  
Milwaukee, Wis. 53201  
(414) 475-2965

Belarus Machinery, Inc.  
7075 West Packland Ct.  
Milwaukee, Wis. 53223  
(414) 355-2000

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6011

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Deutz Corp.  
Agricultural Equipment Div.  
7585 Ponce de Leon Circle  
Atlanta, Ga. 30340  
(404) 449-6140

Fiat U.S. Representative, Inc.  
Agricultural Machinery Div.  
111 East Wacker Dr., Suite 307  
Chicago, Ill. 60601  
(312) 726-3817

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 643-2000

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-3874

Kubota  
Western Div.  
Box 7020  
Compton, Calif. 90224  
(213) 537-2531

British Leyland Ltd.  
Unicentre  
Lords Walk  
Preston PRI IDR, Lancs.  
England

Long Manufacturing N.C., Inc.  
Tarboro, N.C. 27886  
(919) 823-4151

Massey Ferguson, Inc.  
1901 Bell Ave.  
Des Moines, Iowa 50315  
(515) 247-2011

McKee Brothers Ltd.  
Box 70  
Highway 85  
Elmira, Ontario, Canada N3B 2Z9  
(519) 669-5115

Hefty Tractor Co.  
Box 188  
Juneau, Wis. 53039  
(414) 386-2401

Hinomoto Diesel Tractors  
Box 42564  
Houston, Tex. 77042  
(713) 776-6790

Same and Lamborghini Tractor  
of North America, Inc.  
515 Park Ave.  
New York, N.Y. 10022  
(212) 751-0289

Satoh Tractors  
Sumatoma Corp.  
345 Park Ave.  
New York, N.Y. 10022  
(212) 985-7000

Steyr Damlier, Puch Agriculture  
St. Valentin Works  
A4300 St. Valentin  
Austria

White Farm Equipment  
White Motor Corp.  
2625 Butterfield Rd.  
Oak Brook, Ill. 60521  
(312) 887-0110

Yanmar Diesel Div.  
Mitsui and Company USA, Inc.  
476 Country Club Rd.  
Bensenville, Ill. 60106  
(312) 860-4670

# All-Wheel Drive Tractors

## Function

All-wheel drive tractors generally offer more power and traction than rear-wheel drive tractors. Large all-wheel drive tractors were developed to farm vast, open areas.

## Description

All-wheel drive tractors are powered by diesel engines and power is supplied to all wheels for maximum traction. All but the smallest models feature either articulated steering or independent steering of both front and rear wheels. Hydraulic and power-take-off attachments are available and three-point hitches are usually standard. Most all-wheel drive tractors are large machines designed for maximum production (appendix A).

## Techniques

High production with all-wheel drive tractors is achieved by pulling very wide implements or different types of

implements in tandem. The tractors are capable of speeds over 15 mph (24 km/hr), but are usually operated at lower speeds. The tires can be filled with ballast for additional weight and traction. Comfortable enclosed cabs allow operation for extended periods under most weather conditions.

## Capabilities

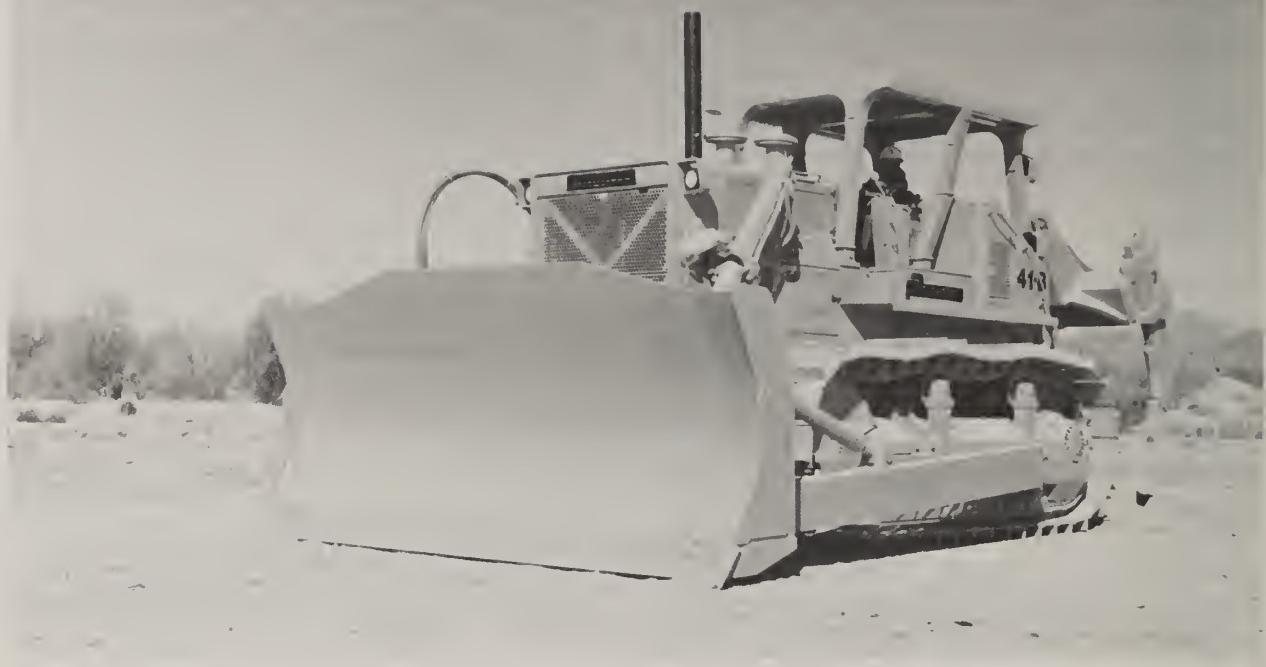
All-wheel drive tractors are especially suited to large open areas. Enough power and traction is available, in many cases, for tillage, seedbed preparation, and seeding to be accomplished in a single pass.

## Limitations

All-wheel drive tractors are used primarily for agricultural applications on large farms and ranches. They are not well suited to steep slopes or rough terrain. Soil compaction or destruction of soil structure may result if rubber-tired tractors are operated on areas that are too wet.



*All-wheel drive tractor with independent steering of front and rear wheels.*



*Large crawler tractor.*

#### Specifications

Power ratings to 760 hp (567 kW)  
Maximum pull over 50,000 lb (22,680 kg)  
Speed at maximum pulling power 4.3 to 8.7 mph (6.9 to 14 km/hr)

Additional information may be obtained from the Nebraska Tractor Test Laboratory, University of Nebraska, East Campus, Lincoln, Nebr. 68503.

#### Availability

Allis Chalmers  
Agricultural Equipment Div.  
Box 512  
Milwaukee, Wis. 53201  
(414) 475-2965

Belarus Machinery, Inc.  
7075 West Parkland Ct.  
Milwaukee, Wis. 53223  
(414) 355-2000

Big Bud Tractors, Inc.  
Box 1111  
Havre, Mont. 59501  
(406) 265-5887

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6011

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Ferrari  
Officine Meccaniche  
Ferrari S.P.A.  
42045 Luzzara  
Italy

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 643-2000

Gebruder Holder Gmbh & Co.  
Maschinen Fabrik  
Box 66  
D7418 Metzingen  
Federal Republic of Germany

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-3874

M-R-S Manufacturing Co.  
Box 199  
Flora, Miss. 39071  
(601) 879-3151

Massey Ferguson, Inc.  
1901 Bell Ave.  
Des Moines, Iowa 50315  
(515) 247-2011

Muir-Hill, Ltd.  
Bristol Rd.  
Groucester, GL15RX  
England

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4450

Steiger Tractor, Inc.  
3101 First Ave.  
Fargo, N.Dak. 58102  
(701) 293-4400

Versatile Manufacturing Ltd.  
1260 Clarence Ave.  
Winnipeg, Manitoba, Canada R3T 1T3  
(240) 284-6100

White Farm Equipment  
White Motor Corp.  
2625 Butterfield Rd.  
Oak Brook, Ill. 60521  
(312) 887-0110

# Crawler Tractors

## Function

Crawler tractors are used on rough terrain, on steep slopes, or when moving large implements. They are usually equipped with standard dozer blades. Crawler tractors are widely adaptable to a variety of range improvement or reclamation applications.

## Description

Crawler tractors move over a pair of steel tracks that revolve around a series of rollers. They are powered by large diesel engines and are equipped with three- to six-speed manual, automatic, or power shift transmissions or with hydrostatic transmissions. Equipment can be attached to the hydraulic systems of the tractors or controlled by cable winches. Many hitches and attachments are available. Crawler tractors come in a wide variety of sizes (appendix B).

## Techniques

Crawler tractors literally build their own road by continually laying down and picking up their steel tracks.

The machines are steered by braking or reducing power to either the right or left track. Hydraulic functions are controlled from the cab by the operator.

## Capabilities

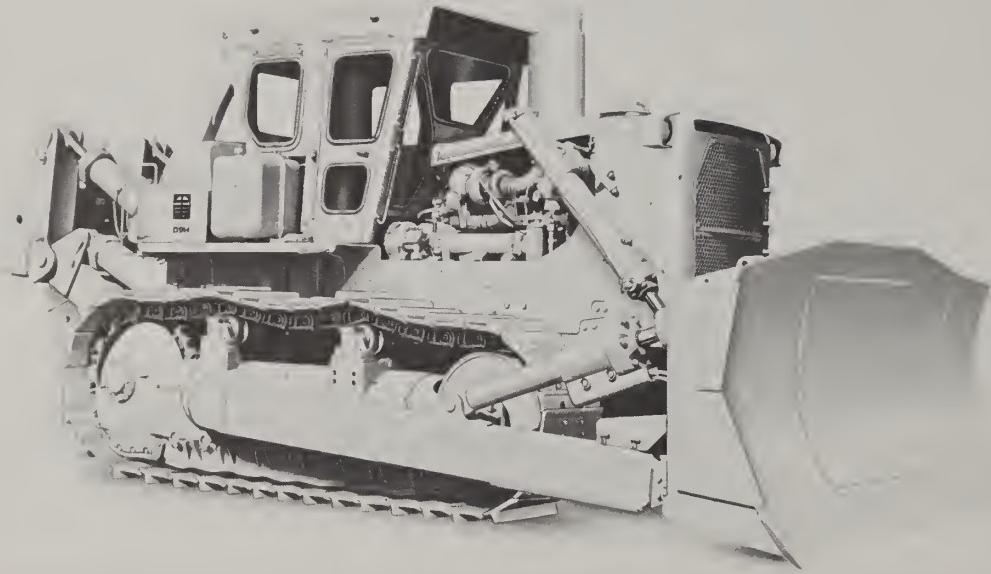
Crawler tractors are very versatile prime movers. They can move tremendous loads and can negotiate slopes of over 70 percent with proper precautions and work on slopes up to 35 percent. They are well suited to rough terrain and areas where objects could damage rubber tires. Crawler tractors are rugged machines and can be operated under extreme conditions. Small crawler tractors are maneuverable and can treat small, confined areas. Large tractors may be used side by side or in tandem for added power.

## Limitations

The top speeds of crawler tractors are generally slow, under 7 mph (11 km/hr). Tracks with grousers worn to 2 in (5 cm) or less may have reduced traction. Fragile lands are easily damaged by careless operation of crawler tractors.



*Crawler tractor piling brush.*



*Crawler-mounted dozer.*

#### Specifications (See appendix B)

##### Power ratings (flywheel):

39 to 700 hp (29 to 522 kW) single

820 hp (611 kW) tandem

Speed to 7.3 mph (11.7 km/hr)

#### Availability

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6011

Caterpillar Tractor Co.  
100 Northeast Adams  
Peoria, Ill. 61629  
(309) 675-1000

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Fiat-Allis Construction Machinery, Inc.  
106 Wilmont Rd.  
Deerfield, Ill. 60015  
(312) 948-5500

International Harvester Co.  
Payline Group  
600 Woodfield  
Schaumburg, Ill. 60172  
(312) 884-3361

Komatsu America Corp.  
555 California St.  
San Francisco, Calif. 94104  
(415) 391-4120

Massey-Ferguson, Inc.  
1901 Bell Ave.  
Des Moines, Iowa 50315  
(515) 247-2011

Terex Div.  
General Motors Corp.  
Hudson, Ohio 44236  
(216) 655-5000

## Controlling Plants with Equipment

The equipment included in this section is primarily for the control of noxious plants by mechanical means, although many of these treatments are combined with other control treatments in the overall range improvement or land reclamation prescription. This equipment is intended to remove brush competition for natural re-establishment of grasses or broadcast seeding. Equipment better suited for seedbed preparation is listed under *Ground Preparation*.

Mechanical treatments are generally the most expensive control techniques, ranging up to \$70 per acre (\$135 per hectare). The effectiveness of mechanical control, as well as the particular method used, depends on: (1) the characteristics of the plant species on the site, (2) the site potential, (3) the soil type and structure and, (4) topography and terrain. Mechanical control may be the only practical management alternative in stands where herbicides would be ineffective or produce undesirable impacts, and fire would prove difficult to control or adversely affect air quality.

### Standard Dozers

#### Function

Dozers are very versatile machines for range improvement and disturbed land reclamation. They are used for cutting and crushing brush, grubbing trees and stumps, piling or windrowing debris, building firebreaks, leveling, terracing, and road construction. Dozers are also basic surface mining support tools.

#### Description

Standard dozers are solid, soil-pushing blades mounted on a tractor. They are usually attached to crawler tractors, but they can be used with rubber-tired prime movers. The larger blades are front-mounted to concentrate the weight and power of the tractors behind them. The blade height can be hydraulically controlled by the operator. The tilt and angle of the blade may be adjusted manually or hydraulically. Smaller blades are sometimes mounted at the rear of a tractor. Blades up to 20 ft (6.1 m) can be mounted on a single tractor.

#### Techniques

Standard dozers often level shrubs and small trees, which are then treated with a towed implement in the same pass. This is accomplished best by holding the blade slightly above the ground during the pass. Larger trees are treated by pushing them over with one pass, and severing their roots with a second. Standard dozers are well suited to clearing the land down to mineral soil, which is essential for building firebreaks and constructing roads. They sometimes pile or windrow debris prior to burning. Production rates vary from  $\frac{1}{4}$  to  $1\frac{1}{2}$  acres (.1 to .6 ha) per hour for brush clearing and crushing.

acres (.1 to .6 ha) per hour for brush clearing and crushing.

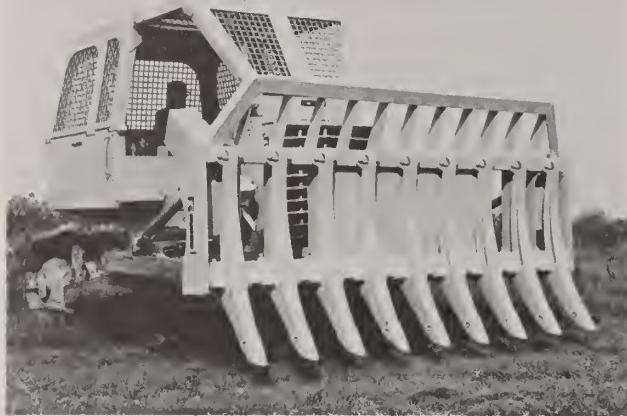
In strip mine operations, standard dozers are used for tasks such as removing overburden, reshaping spoils piles, and spreading topsoil. Dozers occasionally terrace slopes to reduce runoff and prevent erosion.

#### Capabilities

Standard dozers can be adapted to many jobs with few modifications. Tractor-mounted dozers operate on slopes of over 70 percent, although practical range improvements should be limited to slopes of 30 percent or less. Heavier blades tend to impair tractor efficiency on steep slopes. Standard dozers are effective in removing scattered stands of large brush or trees and in preparing areas for broadcast burning.

#### Limitations

Standard dozers have little effect on young plants with flexible stems. Effective control of sprouting plants requires that their root crowns be removed from the soil, which may be too time consuming for economical dozer operation or may cause excessive erosion. Excess soil disturbance must be avoided when operating a standard dozer. Too much dirt scraped into brush piles results in poor burning success. Areas with many large rocks or extremely difficult terrain should be avoided. Wheeled dozers are limited to slopes of less than 20 percent because of poor traction.



*Multi-application land-clearing rake.*

## Specifications

Blade widths to 20 ft (.1 m)  
Power requirements (flywheel) 39 to 700 hp  
(30 to 522 kW)

## Availability

Most crawler tractors come equipped with standard blades. Standard dozer blades are also available from manufacturers or suppliers of construction or land clearing equipment. Light-duty blades are available from several farm implement manufacturers and farm equipment dealers.

For the most part, brush rakes replace the standard dozer blade, but some models may be attached directly to standard blades and can be easily removed. A few rakes are towed. Light-duty spring tooth rakes are available also, but generally are not suited for range work. Some of these can be mounted on the rear of wheeled tractors.

## Techniques

Brush rakes are well suited to piling brush because dirt is filtered through the rake teeth and not scraped into the brush piles. This assures successful burning or easy removal. Brush rakes remove trees and brush with minimum soil displacement. When operated with the rake teeth in the ground, brush rakes can uproot sprouting shrubs, but this also eliminates desirable understory plants. Best results are obtained in dry sandy soil. Production rates average about 1.2 acres (.5 ha) per hour.

## Limitations

The rake design prohibits scraping or blading. A removable rake attached to a standard dozer blade might prove useful where scraping or grading is foreseen. These detachable rakes are not recommended for heavy clearing, or in situations where front-end weight might be limiting.

## Capabilities

Because the soil and small debris are sifted through the rake, brush rakes offer less resistance to tractor movement than standard blades. Most brush rakes are also lighter than standard dozer blades, which allows safer, more efficient operation on steep slopes.

# Brush Rakes

## Function

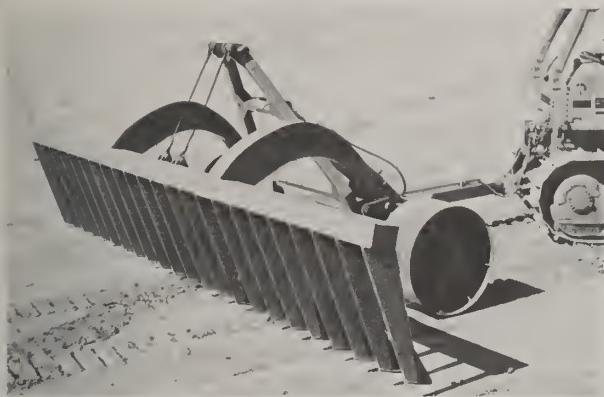
Brush rakes are designed to pile brush and slash prior to burning. They also remove brush and trees and scarify soil.

## Description

Brush rakes consist of several curved teeth attached vertically to a heavy-duty frame. Most rakes feature replaceable tips for the rake teeth. Brush guards can be attached on top of the frame to protect the tractor and operator.



*Detachable brush rake.*



*Towed root rake.*

## Specifications

Blade length 7 ft to 14 ft 9 in (2.1 to 4.5 m)  
Tooth penetration 11 to 24 in (28 to 61 cm)  
Tooth spacing 7.5 to 23 in (19 to 58 cm)  
Power requirements (flywheel) 172 to 290 hp  
(128 to 216 kW) recommended

## Availability

### Standard blade replacements:

Fleco Corp.  
Box 2370  
Jacksonville, Fla. 32203  
(904) 354-8361

Holt Machinery Co.  
Box 658  
San Antonio, Tex. 78293  
(512) 648-1111

Rockland Manufacturing Co.  
Box 5  
Bedford, Pa. 15522  
(814) 623-1115 or (800) 458-3773

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4450

Todd N. Pemberton, Inc.  
Box 899  
Orlando, Fla. 32750  
(305) 831-6688

Unitool Attachments, Inc.  
1607 Woodland Ave.  
Columbus, Ohio 43219  
(614) 252-4908

Young Corp.  
Box 3522  
3231 Utah St. South  
Seattle, Wash. 98124  
(206) 624-1071

### Standard blade attachments:

Fleco Corp.  
Box 2370  
Jacksonville, Fla. 32203  
(904) 354-8361

H&L Tooth Co.  
1540 South Greenwood Ave.  
Montebello, Calif. 90640  
(213) 721-5146

Holt Machinery Co.  
Box 658  
San Antonio, Tex. 78293  
(512) 648-1111

Rivinius, Inc.  
Rural Route 2, Box 63  
Eureka, Ill. 61530  
(309) 467-2303

Rockland Manufacturing Co.  
Box 5  
Bedford, Pa. 15522  
(814) 623-1115 or (800) 458-3773

Todd N. Pemberton, Inc.  
Box 899  
Orlando, Fla. 32750  
(305) 831-6688

Unitool Attachments, Inc.  
1607 Woodland Ave.  
Columbus, Ohio 43219  
(614) 252-4908

Young Corp.  
Box 3522  
3231 Utah Ave. South  
Seattle, Wash 98124  
(206) 624-1071

### Towed rakes:

Holt Machinery Co.  
Box 658  
San Antonio, Tex. 78293  
(512) 648-1111

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4950

## Three-Way Dozers

### Function

The three-way dozer is a multi-purpose dozer blade with full hydraulic control. It can remove trees or shrubs, clear land, construct roads, excavate ditches and ponds, dig contour trenches, and rake roots or brush.

### Description

The three-way dozer is a solid dozer blade that is adjustable for height, tilt, angle, and pitch. These functions are controlled hydraulically and can be adjusted by the operator while the tractor is under load. Three-way dozers are available for crawler tractors or large rubber-tired tractors.

### Techniques

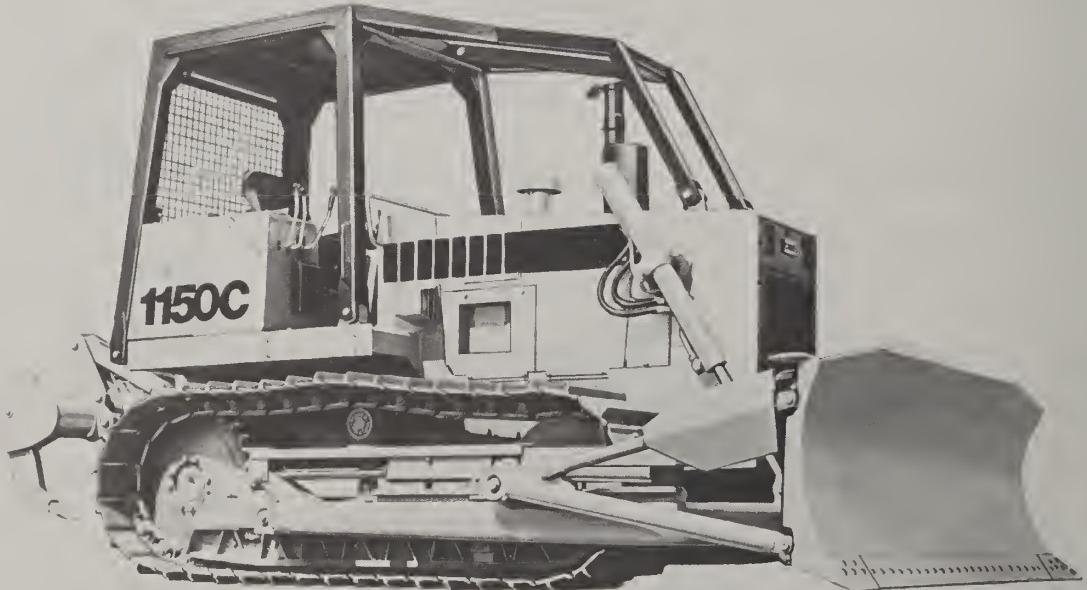
The three-way dozer can be used for a wide variety of tasks. The blade can be tilted into the soil to dig trenches, form basins, or uproot shrubs. It can also be angled for scraping and grading. The hydraulic control permits the operator to easily adjust the blade.

### Capabilities

The hydraulic controls of three-way dozers are responsive and can be operated while under power. Full tilt to either side and back can be accomplished in a matter of seconds. Three-way dozers are very versatile machines, well suited for rangeland and watershed work.

### Limitations

Excessive soil disturbance that may cause erosion should be avoided.



*Three-way dozer featuring hydraulic angle, tilt, and pitch control.*



*Three-way dozer on a rubber-tired tractor.*

## Specifications

### Crawler tractors:

Blade width 6 ft 8 in to 12 ft 4 in (2.0 to 3.8 m)  
Blade height 23 to 38 in (48 to 97 cm)  
Power requirements (flywheel) 39 to 140 hp  
(39 to 104 kW)

### Rubber-tired tractors:

Blade width 12 to 20 ft (3.7 to 6.1 m)  
Blade height 36 in (91 cm)  
Power requirements (drawbar) 125 hp (93 kW)  
minimum

## Availability

### Crawler tractors:

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6011

Caterpillar Tractor Co.  
100 Northeast Adams  
Peoria, Ill. 61629  
(309) 675-1000

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(308) 752-8000

International Harvester Co.  
Payline Group  
600 Woodfield  
Schaumburg, Ill. 60196  
(312) 884-3361

### Rubber-tired tractors:

Dakota Sales Agency  
Box 617  
West Fargo, N.Dak. 58078  
(701) 282-5670

Degelman Industries, Ltd.  
Box 830  
Regina, Saskatchewan, Canada S4P 3B1  
(306) 543-4447

Waldon, Inc.  
201 West Oklahoma  
Fairview, Okla. 73737  
(405) 227-3711

## Clearing Blades

### Function

Clearing blades remove large trees and stumps by cutting them at the ground surface. They are designed to rapidly clear large areas, leaving the area free from stumps or holes.

### Description

Clearing blades are solid dozer blades with cutting edges along the bottom that sever the trees at ground level. The blades may be straight (K-G) or V-shaped, with straight or serrated edges. Large, wedge-shaped stump splitters are attached on the bottom corner of the straight (K-G) clearing blades or in the center of the V-shaped blades.

### Techniques

The stump splitter is on the leading edge of the clearing blade. It splits the tree or stump into sections that are then cut with the blade edges. The angled blade clears the path of debris.

### Capabilities

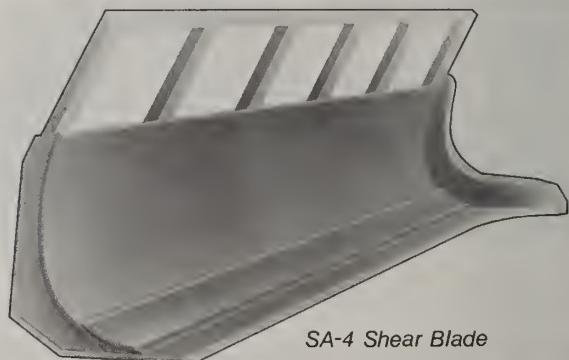
Trees and stumps are removed at ground level with little surface disturbance. V-shaped tree cutters require only one pass to clear a strip, but they cannot be operated beneath the ground. Straight (K-G) clearing blades can be tilted into the ground to grub out stumps.

### Limitations

Clearing blades are specialized tools designed for quick removal of large trees and stumps. Sprouting species are not controlled because growth is removed at the ground surface. Clearing blades should not be used in areas with numerous large rocks.



*V-shaped clearing blade.*



*Straight shearing blade.*

### Specifications

#### V-blade tree cutters:

Cutting width 8 ft 2 in to 14 ft (2.5 to 4.3 m)

Bladed height with brush rack 48 to 66 in  
(122 to 168 cm)

Splitter extension 24 to 48 in (61 to 122 cm)

Power requirements (flywheel) 60 to 260 hp  
(45 to 194 kW)

#### Straight (K-G) blades:

Cutting width 8 ft 11.5 in to 13 ft 3 in  
(2.7 to 4.1 m)

Height 48 to 76.8 in (122 to 195 cm)

Power requirements (flywheel) 60 to 370 hp  
(45 to 276 kW)

## Availability

| V-blade cutters:  | Todd N. Pemberton, Inc.<br>Box 899<br>Orlando, Fla. 32750<br>(305) 831-6688                   | Rome Industries<br>Box 48<br>Cedartown, Ga. 31025<br>(404) 748-4450                       |
|---|---|---|
| Fleco Corp.<br>Box 2370<br>Jacksonville, Fla. 32203<br>(904) 354-8361                         | Unitool Attachments, Inc.<br>1607 Woodland Ave.<br>Columbus, Ohio 43219<br>(614) 252-4908     | Todd N. Pemberton, Inc.<br>Box 899<br>Orlando, Fla. 32750<br>(305) 831-6688               |
| Rockland Manufacturing Co.<br>Box 5<br>Bedford, Pa. 15522<br>(814) 623-1115 or (800) 458-3773 | Straight (K-G) blades:  | Unitool Attachments, Inc.<br>1607 Woodland Ave.<br>Columbus, Ohio 43219<br>(614) 252-4908 |
| Rome Industries<br>Box 48<br>Cedartown, Ga. 31025<br>(404) 748-4450                           | Rockland Manufacturing Co.<br>Box 5<br>Bedford, Pa. 15522<br>(814) 623-1115 or (800) 458-3773 |   |

## Grubbers

### Function

Grubbers remove individual trees or shrubs by severing the root underground and lifting the plants from the ground.

### Description

The grubber is a short, stout blade mounted between two heavy supports. The device is mounted in front of a crawler tractor on, or in place of, the dozer blade. Push bars may also be included. Grubbers with hydraulic control of the blade pitch are being developed for better soil penetration and greater stump splitting capability.

### Techniques

Grubbers are adapted to removing scattered stands of sprouting plants or trees. The grubbers slice beneath the plant and are then raised to lift the plant from the ground. Single blade tree transplanters that use this technique with more care, are also available.

### Capabilities

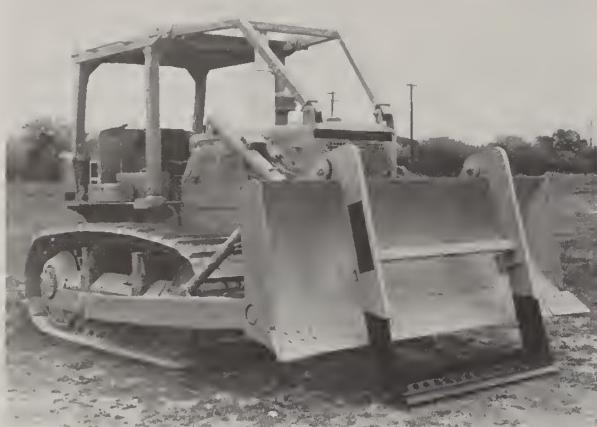
Grubbers control sprouting species by severing the roots. The short blade concentrates tractor power and minimizes soil disturbances. Grubbers are effective for maintenance control of invading brush and for initial control of light to moderate stands.

### Limitations

Because effective grubbing is time consuming, grubbers are not suited for dense stands of vegetation. Such intensive treatment is unnecessary for non-sprouting species where effective control can be accomplished without cutting the roots.



*Shearing blade clearing trees.*



*Detachable grubber mounted on a standard dozer blade.*



*Hydraulic grubber mounted on a C-frame.*



*Single blade transplanter removing a small tree.*

#### Specifications

Blade width 13 to 36 in (36 to 91 cm)  
Power requirements (flywheel) 60 to 120 hp  
(45 to 79 kW)

#### Availability

##### Grubbers:

Holt Machinery Co.  
Box 658  
San Antonio, Tex. 78293  
(512) 648-1111

Grubbers may be fabricated by equipment dealers or local machine shops. Drawings and information are available from:

Texas Agricultural Experiment Station  
Texas A&M University  
Box 1648  
Vernon, Tex. 76384  
(817) 552-9941

##### Single blade tree transplanters:

Hawk, Inc.  
Route 71  
Oswego, Ill. 60543  
(312) 554-3414

Schutts Equipment Co.  
Box 412  
Birmingham, Mich. 48012  
(313) 642-6555

## Root Plows

### Function

Root plowing is a very effective method of controlling undesirable vegetation. Kills of 80 to 100 percent are common on treated areas. Root plowing is most effective when used in combination with broadcast seeding. Burning treatments are sometimes used in conjunction with root plowing, to insure lasting control.

### Description

The root plow is a shallowly V-shaped blade mounted between two shanks. These shanks are attached to a toolbar or to two trailing draft arms. Fins are attached to the top of the blade to cut rhizomes and heave the severed roots to the surface. Some root plows have been constructed by attaching a blade to the bottom of a brush rake. Tractor-mounted models can be raised or lowered hydraulically or with cables.

### Techniques

The blades are pulled laterally through the soil, cutting all roots at the desired depth. The fins attached to the top of the blade provide some vertical cutting action and force the severed roots to the ground surface. The exposed roots are killed by desiccation. Root plowing is most effective in dry, sandy soil during hot weather. Pulling the plow through dry soil requires more power than moist soil, but the plants are less likely to reestablish. Production rates vary 1 to 4 acres (.4 to 1.6 ha) per hour. A soil sifter can be attached to accomplish once-over brush control and seedbed preparation. Plowing depth should be set below the budding zone of the plants.

### Capabilities

Root plows are one of the few implements capable of controlling dense stands of sprouting plants such as mesquite (*Prosopis spp.*). Root plowing is very effective in combination with other treatments in intensive control. The design allows good control of the plowing depth.

### Limitations

Root plowing usually requires seeding for range improvements to be realized, because the treatment also destroys desirable understory plants. The seeding requirements increase the cost of the brush control operation and limit the areas that can be economically

treated. Root plows also favor the spread of prickly pear (*Opuntia spp.*) by removing the brush competition. Root plowed areas with abundant prickly pear will require additional treatment. Root plows should not be operated in rocky soils.



Large root plow.



Toolbar-mounted root plow.



Root plow controlling brush by slicing roots.

## Specifications

### Draft models:

Cutting width 7 ft 2 in to 16 ft 2 in (2.2 to 4.9 m)  
Depth to 36 in (91 cm)  
Power requirements (flywheel) 105 to 370 hp  
(78 to 276 kW)

### Toolbar models:

Cutting width 3 ft to 7 ft 6 in (.9 to 2.3 m)  
Depth to 16 in (41 cm)  
Power requirements (flywheel) 60 to 172 hp  
(45 to 128 kW)

## Availability

### Draft models:

Fleco Corp.  
Box 2370  
Jacksonville, Fla. 32203  
(904) 354-8361

Holt Machinery Co.  
Box 658  
San Antonio, Tex. 78293  
(512) 648-1111

Rockland Manufacturing Co.  
Box 5  
Bedford, Pa. 15522  
(814) 623-1115

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4450

### Toolbar models:

Holt Machinery Co.  
Box 658  
San Antonio, Tex. 78293  
(512) 648-1111

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4450

## Chains and Cables

### Function

An anchor chain, pulled between two tractors, has been a standard brush control treatment for many years. Much of the appeal of chaining lies in its high production and low cost. Chaining is often used in preparation for broadcast burning. It is most effective in old stands of nonsprouting brush. Cables are sometimes used in place of chains, for brush thinning or browse rejuvenation. The action of chains or cables usually provides sufficient soil disturbance to cover broadcast seed.

### Description

Navy surplus anchor chain, destroyer or cruiser type, comes in 90 ft (27.5 m) sections or "shots." The shots are usually cut into 45-ft (13.7 m) sections that are connected with Navy master connector links. Total chain length varies from 90 to 300 ft (27.5 to 91.4 m).

Attempts to improve chaining effectiveness have produced many modifications. The best of these seems to be the Ely chain, constructed by welding hard steel bars or hardsurfaced rails to every link or every third link. The bars should be 1 in (2.5 cm) thick and 3 to 4 in (7.4 to 10.2 cm) wide. The bar ends should extend 4 or 5 in (10 to 13 cm) beyond the links. The rails should be 18 in (26 cm) long and weigh 70 to 90 lb per yd (35 to 95 kg/m). Swivels allow the modified chain to roll, which keeps it free from trash and increases its destructive action. The most recent innovation in chain design involves welding 24 in (61 cm) disks to a chain in an attempt to combine the effectiveness of disking with the economy of chaining for seedbed preparation.

Cables are usually 1½ to 2 in (4.3 to 5 cm) thick. Two or three cables are often used together to provide more weight and increase the whipping action.

## Techniques

The chains or cables are usually towed between two crawler tractors, in a "U" or "J"-shaped pattern. The distance between the tractors should be one-half to two-thirds the length of the chain. Chaining or cabling should be done on the contour to prevent erosion. Two passes are usually recommended, but one may prove adequate. Production rates vary widely, from 15 to 40 acres (6 to 16 ha) per hour one way, depending on terrain difficulty, brush type and density, and operator experience. Special communication systems may be required.

Chains should maintain ground contact for maximum effect, but cables should be towed at high speeds to increase their whipping action. Cabling is generally a less intensive treatment than chaining. Seed can be broadcast from the tractors and covered with soil loosened by the chains or cables.

On slopes over 30 percent, a chain can be attached to a large heavy ball that replaces the lower tractor. The hollow ball is about 5 ft (1.5 m) in diameter and is completely filled with sand, water, or concrete. The filled ball weighs from 2.8 to 5.5 tons (2.5 to 5 metric tons). The chain bows out when pulled and the ball follows an irregular path due to terrain fluctuations and obstructions. Production rates average from .5 to 1.5 acres (2 to 6 ha) per hour with the ball and chain technique.

## Capabilities

Chaining is useful in releasing undergrowth from brush and tree competition. Older brush stands with brittle stems are treated most effectively. Chaining is often used prior to broadcast burning. Cabling is effective in thinning brush and releasing stands. The disk chain may prove useful for more thorough ground preparation.



Disk chain.

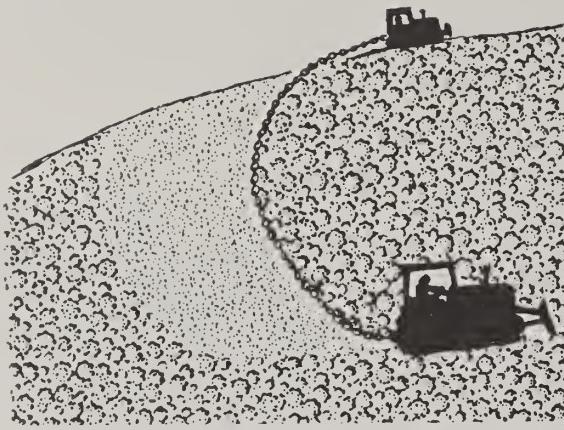
Large areas can be treated quickly and economically. Chains and cables can treat most soil types within practical slope limitations. Erosion is not usually a problem on chained areas if the debris is left in place. The remaining debris can also provide a suitable microclimate for the germination and growth of broadcast seed.

## Limitations

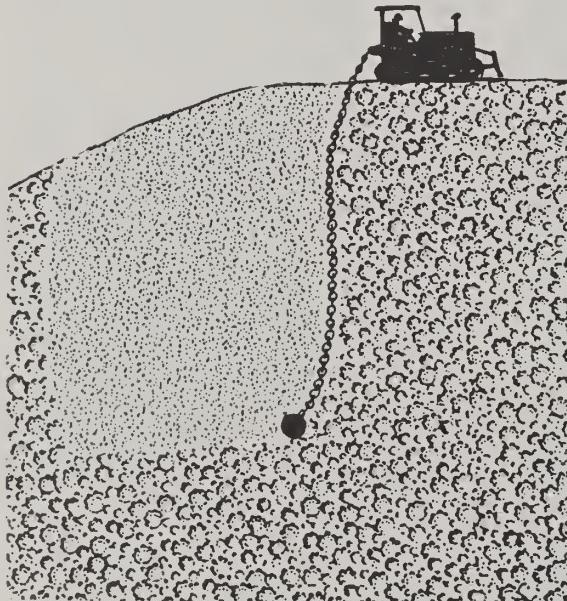
Chaining will not control sprouting plants without additional treatments. Young plants with flexible stems are not greatly affected by chaining operations. Rough terrain and rock outcrops reduce chaining effectiveness, restrict mobility, and make chaining impractical. Cables are less flexible than chains and tend to lose ground contact easily. Modified chains must be properly welded to prevent breakage and hardsurfaced to reduce wear.



Ely chain.



*Proper chaining technique.*



*Ball and chain technique.*

## Specifications

### Two-tractor operation:

Length 90 to 300 ft (27.5 to 91.4 m)

Weight\* 60 to 90 lb/ft (90 to 135 kg/m)

Power requirements (flywheel):

172 hp (128 kW) minimum

190 to 290 hp (142 to 216 kW) recommended

### 5 ft (1.5 m) diameter ball and chain:

Length 60 to 180 ft (18.3 to 48.9 m)

Weight\* 20 to 60 lb/ft (30 to 90 kg/m)

Power requirements (flywheel):

172 hp (128 kW) minimum

260 to 290 hp (194 to 216 kW) recommended

\*excluding modifications

## Availability

Anchor chains, connector links, and steel balls (marine buoys) are available from Navy surplus outlets. Chains can be modified at most local machine shops.

Cables are available from suppliers of construction or logging equipment.

Drawings (No. 568) are available from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

For additional information refer to:

Cain, D. 1971. The Ely Chain. USDI Bureau of Land Management Handbook. 32 p.

Disk-chain information may be obtained from:

Texas Agricultural Experiment Station  
Texas A&M University  
Box 1658  
Vernon, Tex. 76384  
(817) 552-9941

# Rails

## Function

Sections of railroad rails are dragged behind a tractor to crush and break brush and allow forage plants to increase coverage. Railing is especially effective when used in conjunction with herbicide treatments and is sometimes used to cover broadcast seed.

## Description

The three main rail configurations are the A-rail, the Supp rail, and the rail drag. The A-rail is a rigid frame pulled with the apex forward. The Supp rail is a three-sectioned straight rail built with flexible end couplings between sections. The sections are end-to-end at right angles to the direction of travel. Two drag rails, spread by a cross rail, are attached to each section. The rail drag, designed by the USDI Bureau of Land Management (BLM), consists of a single 90 lb/ft (135 kg/m) lead rail, or 10 in (25 cm) channel iron section, 33 ft (10 m) long, followed by two 16 ft (4.9 m) rails and three 11 ft (3.4 m) rails of lesser weight. The rails are attached to each other with chains forming three parallel lines of equal length.

## Techniques

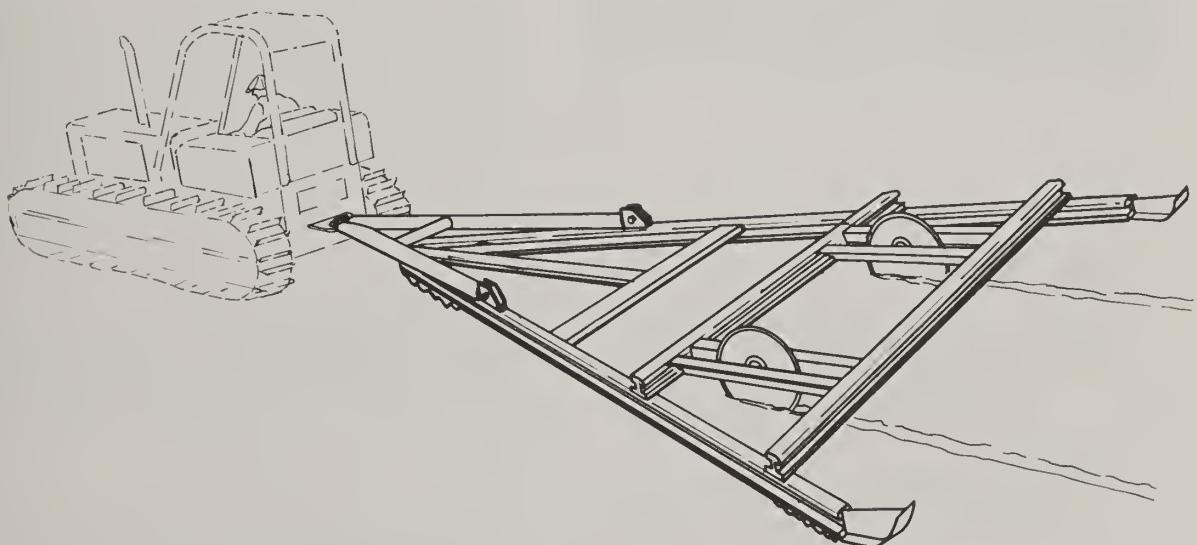
The rails are dragged over an area, maintaining as much ground contact as possible. Two passes are recommended. Seed is sometimes broadcast in front of the rails, but seed coverage has been inadequate except in very loose soils. Railing is most effective when the soil and vegetation are dry.

## Capabilities

Railing is a low cost method of treating mature stands of brush with a fair understory of desirable forage. Railing generally has little effect on grasses. Acceptable kills of prickly pear have been achieved under certain conditions. Railing can be used to cover broadcast seed in loose soil.

## Limitations

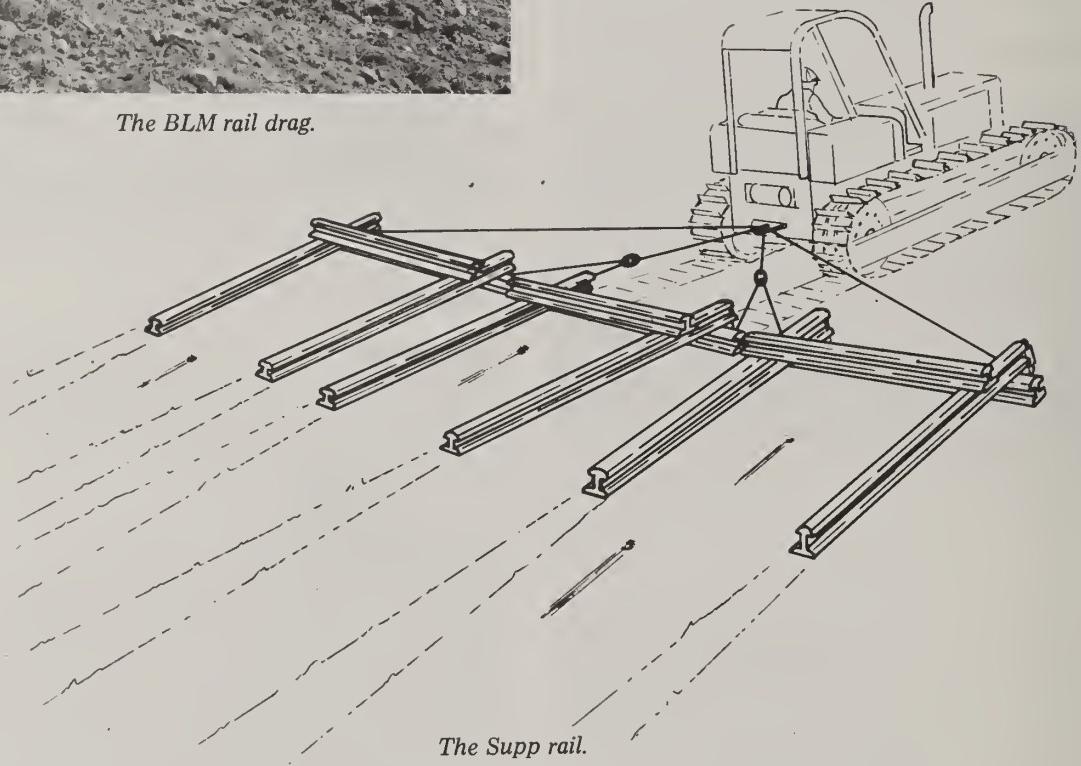
Railing does not control sprouting species or young plants with flexible stems. It has little effect on undesirable herbaceous plants. Breakage may occur in areas with large rocks or rock outcrops. Effective railing is limited to fairly level ground.



*The "A" rail.*



*The BLM rail drag.*



*The Supp rail.*

## Specifications

### A-rail:

Width 16.5 ft (5 m)  
Power requirements (flywheel) 37 to 60 hp  
(28 to 45 kW)

### Supp rail:

Width 33 ft (10 m)  
Power requirements (flywheel) 37 to 60 hp  
(28 to 45 kW)

### Rail drag:

Width 33 ft (10 m)  
Power requirements (flywheel) 42 to 72 hp  
(31 to 54 kW)

## Availability

Rails can be manufactured at local machine shops. New materials and sturdy welds should be specified because used rails and unsound welds are major causes of breakage.

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

# Pipe Harrow

## Function

The pipe harrow thins low brittle shrubs, scarifies the soil surface, and covers broadcast seed. It is effective in rocky areas where other implements are limited.

## Description

The pipe harrow consists of spiked pipes that are trailed behind a spreader bar. The pipes are attached to the spreader bar with swivels at equal intervals to allow the pipes to rotate freely and clean themselves of trash. A modified pipe harrow, smaller and less expensive than the original design, has been developed by USDA Forest Service District personnel in Arizona.

## Techniques

The pipe harrow is dragged over the area to be treated. Two passes are recommended for brush treatment. The pipe harrow is often used for seedbed preparation on areas that are too rocky for other treatments, such as rocky scablands, abandoned roads, and excavation scars. It is especially effective immediately following a burn. Seed is often broadcast during the pipe harrow operation for once-over treatment of the disturbed area.

## Capabilities

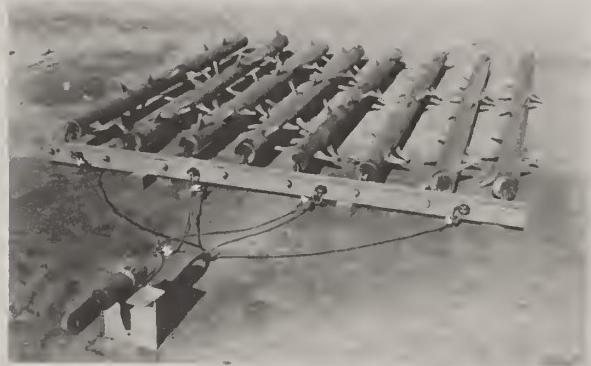
The pipe harrow was designed specially for rocky land, where it effectively removes small, brittle brush; scarifies the soil; and covers the broadcast seed. Perennial grasses or tree seedlings are not greatly disturbed by pipe harrows. Breakage and operating costs are low. The pipe harrow is used extensively in the southwest.

## Limitations

The pipe harrow is limited to rocky areas because it brings many large rocks to the surface and does not function well in rock-free soils. Control of plants other than small, brittle shrubs should not be expected. The pipe harrow must be disassembled for transport.

## Specifications

Width 8 to 14 ft (2.4 to 4.3 m)  
Pipe length 10 ft to 11 ft 5 in (3 to 3.5 m)  
Pipe diameter 2 to 4 in (4.1 to 10.2 cm)  
Power requirements (flywheel):  
42 to 60 hp (31 to 45 kW) single  
72 to 105 hp (54 to 78 kW) dual



*Original pipe harrow.*



*Modified pipe harrow.*

## Availability

Drawings (RMI-01 and 02) are available from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

Drawings for the modified design are available from:

USDA Forest Service  
Coconino National Forest  
Blue Ridge Ranger District  
Happy Jack, Ariz. 86024  
(602) 477-2255

## Rolling Choppers

### Function

Rolling choppers cut and crush brush, small trees, or slash. They can also pit and imprint the soil by making small deep holes, intermittent depressions, or minute trenches in the ground surface to increase infiltration and retain runoff, which provides more water for plant growth. Rolling brush cutters are sometimes used before broadcast burning.

### Description

Rolling choppers are large hollow drums with chopping blades, ridges, or, in some cases, spikes, welded or bolted onto the outer surface of the drum cylinder. One type attaches directly to a dozer blade, but most units are towed in single, dual, triple, or tandem configurations. Rolling choppers are usually filled with water for additional weight and increased effectiveness.

Self-propelled rolling choppers, or crushers, up to 24 ft (7.3 m) wide are available. These self-propelled machines have three large, electrically driven cutting drums that also function as wheels. Power is supplied by a diesel-driven generator.

### Techniques

Rolling choppers mounted on dozer blades simply extend the crushing effect of the crawler tracks to the full width of the tractor. Towed units chop as well as crush for better brush or slash treatment. When these choppers are towed in tandem, they are often set at a slight angle to each other to give the blades a shearing action as they are pulled forward by the tractor. On steeper slopes these units should be towed up and down the slopes to prevent erosion and to avoid sideslip. Rolling choppers should move at high speeds for maximum effect. Production rates vary from 2 to 9 acres (.8 to 3.6 ha) per hour.

Large, self-propelled crushers treat extensive, large scale clearing operations. Average production rates of 3 to 4 acres (1.2 to 1.6 ha) per hour have been achieved with these machines.

### Capabilities

The crushing and chopping action of rolling choppers effectively controls non-sprouting brush up to 5 in (12.7 cm) in diameter. A single pass often provides adequate control. Some of these implements can pit and imprint the ground surface to increase water holding capabilities. Rolling choppers can operate on slopes of 35 to 40 percent, although 15 to 20 percent appears to be the maximum for towing on the contour.

Large self-propelled machines can fell large trees and crush slash. They can operate on slopes up to 45 percent.

### Limitations

Permanent control of sprouting species is not realized because the root crowns remain intact. The action of the cutting blades may contribute to erosion. The cutting blades are easily damaged by numerous large rocks. There may be some difficulty in transporting the large brush cutting machines.



Cutter-crusher compactor towed by crawler-tractor.



Towed rolling chopper.



Tandem rolling choppers towed in an offset configuration.



*Large self-propelled rolling chopper.*

## Specifications

### Blade mounted models:

Cutting width 6 to 10 ft (1.8 to 8 m)  
Drum diameter 21 to 24 in (53 to 61 cm)  
Cutting depth 1 to 2.4 in (2.4 to 6.3 cm)  
Power requirements (flywheel) 172 to 290 hp  
(128 to 216 kW)

### Towed models:

Cutting width 5 to 16 ft (1.5 to 4.9 m); 8 to 10 ft  
(2.4 to 3 m) recommended  
Drum diameter 2 to 6 ft (.6 to 1.8 m)  
Cutting depth 6 to 10 in (15 to 25 cm)  
Weight 3,000 to 67,310 lb (1,360 to 30,530 kg)  
Power requirements (flywheel) 60 to 370 hp  
(45 to 276 kW)

### Self-propelled models:

Cutting width 16 to 24 ft (4.9 to 7.3 m)  
Drum diameter 5 ft 4 in and 5 ft 10 in (1.6 to 1.8 m)  
Cutting depth 8 in (20 cm)  
Weight 76,000 and 130,000 lb (34,473 and 58,969 kg)  
Power ratings 200 hp (149 kW) at each wheel (drum)

## Availability

### Blade mounted:

American Tractor Equipment Co.  
9131 San Leandro St.  
Oakland, Calif. 94603  
(415) 638-2466

Young Corp.  
Box 3522  
Seattle, Wash. 98124  
(206) 624-1071

### Towed:

E. L. Caldwell & Sons, Inc.  
Box 9316  
Corpus Christi, Tex. 78408  
(512) 884-3521

Fleco Corp.  
Box 2370  
Jacksonville, Fla. 32203  
(904) 354-8361

Marden Manufacturing Co.  
Box 1157  
Auburndale, Fla. 33823  
(813) 967-1111

Rockland Manufacturing Co.  
Box 5  
Bedford, Pa. 15522  
(814) 623-1115 or (800) 623-1115

### Self-propelled:

Marathon LeTourneau Co.  
Longview Div.  
Box 2307  
Longview, Tex. 75601  
(214) 753-4411

# Rotary Cutters

## Function

Rotary cutters remove weeds or brush at the ground level and chop the material into mulch for maintenance control of undesirable vegetation on previously treated areas or along highway, railroad, and power line rights-of-way.

## Description

Rotary cutters have blades that rotate in a horizontal plane on a vertical shaft. The blades are enclosed with shrouds to increase the mulching effect and for safety. The cutters may be hydraulically driven or attached to the power-take-off (PTO) of a tractor.

Rotary cutters can be mounted on a tractor, or towed. Some models are mounted on retractable booms that can be maneuvered hydraulically into various cutting positions.

## Techniques

Brush and weeds are cut close to the ground as the rotary cutter passes over them. Plant residues are mulched and scattered. Production rates are variable, ranging from less than  $\frac{1}{4}$  acre (.1 ha) to 12 acres (3.7 ha) per hour, depending on the size of the machine and operating conditions.

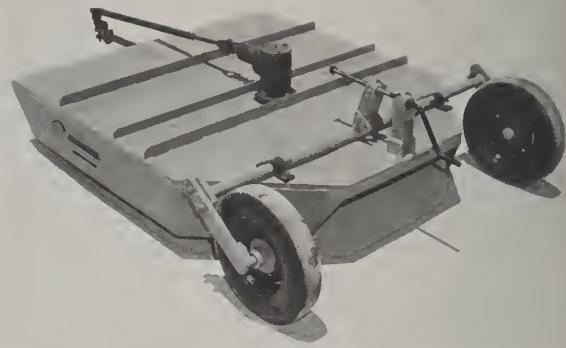
## Capabilities

Trees and shrubs up to  $1\frac{1}{2}$  in (3.8 cm), and sometimes up to 3 in (7.6 cm), in diameter can be cut and shredded with rotary cutters. The cutters have effectively maintained pastures, rangeland, and rights-of-way.

Rotary cutters are effective in controlling upright annuals. They are useful for frequently repeated treatments of sprouting species. Rotary cutters can operate on slopes up to 30 percent. Boom-mounted models are extremely maneuverable and well adapted to uneven terrain.

## Limitations

Treatments with rotary cutters usually have to be repeated frequently to be effective. Rotary cutters also present a safety hazard because chips and other debris are widely scattered by the blades. The machines should not be operated in rocky areas.



*Typical power-take-off rotary cutter.*



*Hydraulically powered rotary cutter.*



*Boom-mounted rotary cutter.*

## Specifications

### Tractor mounted or towed:

Cutting width 4 ft 2 in to 16 ft (1.3 to 4.9 m)  
Blade tip velocity 10,000 to 14,000 ft/min  
(3,050 to 4,270 m/min) recommended  
Power requirements (PTO):  
50 to 200 hp (37 to 150 kW)  
12 hp per ft (30 kW/m) of cutting width

### Boom mounted:

Cutting width 5 to 7 ft (1.5 to 2.1 m)  
Control area radius to 28 ft (8.5 m)  
Power requirements:  
60 to 84 hp (45 to 63 kW)  
12 hp per ft (30 kW/m) of cutting width

## Availability

### Tractor mounted or towed:

Austin Products, Inc.  
Servis Div.  
Box 222117  
Dallas, Tex. 75222  
(214) 651-0733

Brillion Iron Works  
200 Park Ave.  
Brillion, Wis. 54110  
(414) 756-2121

Bush Hog  
Box 1039  
Selma, Ala. 36701  
(205) 872-6261

E. L. Caldwell & Sons, Inc.  
Box 9316  
Corpus Christi, Tex. 78408  
(512) 884-3521

Cartner Corp.  
Box 262  
Cambridge, Ohio 43725  
(614) 439-2725

Continental Belton Co.  
Box 660  
Belton, Tex. 76513  
(817) 939-3731

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

FMC Corp.  
Agriculture Machinery Div.  
Box 818  
Minden, La. 71055  
(318) 377-0385

Ford Tractor Operations  
2500 East Maple  
Troy, Mich. 48084  
(313) 643-2000

Independent Manufacturing Co.  
Box 300  
Neodesha, Kans. 66757  
(316) 325-3061

Massey-Ferguson, Inc.  
1901 Bell Ave.  
Des Moines, Iowa 50315  
(515) 247-2011

Napier Grasslands Pty., Ltd.  
Box 244  
Taree, NSW, 2430  
Australia

Rears Manufacturing Co.  
2140 Prairie Rd.  
Eugene, Oreg. 97402  
(503) 688-1002

Triumph Machinery Co.  
Box 610  
Hackettstown, N. J. 07840  
(201) 852-0222

United Farm Tools, Inc.  
Box 9175  
South Charleston, W. Va. 25309  
(304) 768-8221

Woods  
Division of Hesston Corp.  
Highway 2 South  
Oregon, Ill. 61061  
(815) 732-2141

### Boom Mounted:

Harrington Manufacturing Co.  
Box 269  
Lewistown, N. C. 27849  
(919) 348-2531

Portec, Inc.  
RMC Div.  
Box 1888  
Pittsburgh, Pa. 15230  
(412) 782-1000

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4450

## Rotobeaters

### Function

Rotobeaters cut brush at the ground level and chop it into mulch. They are often used for maintenance plant control on previously treated areas.

### Description

Rotobeaters have swinging stirrup cutters, hammers, or flails attached to a wide horizontal shaft that revolves at high speeds. These attachments are easily removed for servicing or replacement. Rotobeaters are powered hydraulically, with power-take-off attachments or by separate gasoline engines. The cutting apparatus is enclosed in shrouds that provide safety and contribute to the shredding action by keeping the material near the cutters. Rotobeaters can be mounted on the rear or sides of tractors or small front-end loaders.

### Techniques

Rotobeaters are driven over the area to be treated. The high-speed revolving action chops and shreds the vegetation. The material is forced down and backward,

where it is deflected back into the flails by the ground or shrouding. This produces a mulch of shredded material that is usually left in place. Production rates vary widely, from less than  $\frac{1}{4}$  acre (.1 ha) to 12 acres (3.7 ha) per hour, depending on the size of machine and difficulty of the operation. Average rates are usually between 1.5 and 3 acres (.61 to 1.2 ha) per hour.

### Capabilities

Most rotobeaters can handle stems up to 2 in (5.1 cm) in diameter. Certain annuals may be effectively controlled by rotobeaters. Slopes up to 35 percent have been treated. Rotobeaters are safer than rotary cutters because chips and debris are not thrown outward by the action of the flails.

### Limitations

Because rotobeating is a surface treatment, it must be repeated often to control most shrubs. Rotobeater flails are quickly dulled in rocky areas.



*Three gangs of rotobeater mowers featuring both hydraulic and power-take-off drive.*



*Power-take-off stalk shredder.*

## Specifications

### Cutting width:

5 ft to 7 ft 4 in (1.5 to 2.3 m) single units  
to 18 ft 10 in (5.5 m) with three unit gangs  
Flail velocity 10,000 to 14,000 ft/min (3,050 to 4,270  
m/min)

### Power requirements (PTO):

60 to 226 hp (45 to 157 kW)

12 hp per ft (30 kW/m) of cutting width

## Availability

Blair Manufacturing Co.  
929 East Washington  
Blair, Nebr. 68008  
(402) 426-2151

Cartner Corp.  
Box 262  
Cambridge, Ohio 43725  
(614) 439-2725

Dandle Manufacturing Co.  
Box 687  
Chico, Calif. 95927  
(916) 345-0210

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

FMC Corp.  
Agricultural Machinery Div.  
Box 818  
Minden, La. 71055  
(318) 377-0383

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 643-2000

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-3874

Mott Corp.  
500 Shawmut Ave.  
LaGrange, Ill. 60525  
(312) 354-7220

Napier Grasslands Pty., Ltd.  
Box 244  
Taree, NSW, 2430  
Australia

United Farm Tools, Inc.  
Box 9175  
South Charleston, W.Va. 25309  
(304) 768-8221

Woods  
Division of Hesston Corp.  
Highway 2 South  
Oregon, Ill. 61061  
(815) 732-2141

## Shredders

### Function

Shredders initially treat and maintain control of heavy brush. Frequently they masticate logging slash. Shredders remove the brush or slash near ground level and shred the material into a fine mulch.

### Description

Shredders are large, self-propelled or self-powered brush cutters. They may be of either rotary blade or rotobeater design. Shredders are usually mounted on the front of special rubber-tired or tracked prime movers with hydrostatic transmissions. Some are designed to be mounted on standard rubber-tired or crawler tractors.

### Techniques

On most units, maximum cutting power is maintained, regardless of tractor speed, by hydrostatic transmission drives or separate engines on the cutting units. Production rates of .5 to 3.7 acres (.1 to 1.5 ha) per hour have been reported for heavy brush and logging slash treatments.

### Capabilities

Shredders on crawler tractors can handle heavy brush conditions on slopes from 30 to 35 percent. Rubber-tired shredders can negotiate 15 to 20 percent slopes. The mulch that remains after treatment helps prevent erosion and usually does not smother the undergrowth. Shredders are useful for rights-of-way, clearing, and forest site preparation.

### Limitations

Although shredding effectively removes heavy brush growth, it is an expensive method of brush control. Lasting control usually is not achieved because the roots of the plants remain intact. Repeated treatments are necessary for effective control. Rotary cutter-shredders have exposed blades that decrease the shredding action and increase the safety hazard by throwing the cut brush to the side. The front-mounted design creates a serious dust problem with both types of shredders. The dust becomes highly objectionable and greatly reduces operator visibility. Shredders should be operated in areas relatively free from rocks.



*Rotobeater shredder mounted on a crawler-tractor.*



*Self-propelled rotobeater shredder masticating brush.*



*Rotary blade shredder.*

### Specifications

Cutting width 5 to 8 ft (1.5 to 2.4 m)  
Power ratings 91 to 188 hp (68 to 140 kW)

### Availability

#### Rotary blade:

Bombardier Ltd.  
Valcourt, Quebec, Canada, J0E 2L0  
(514) 532-2211

Kershaw Manufacturing Co.  
Drawer 9328  
Montgomery, Ala. 36108  
(205) 263-5581

National Hydro Ax, Inc.  
Box 568  
Owatonna, Minn. 55060  
(507) 451-8654

Pettibone Corp.  
Alabama Div.  
Box 68  
Greenville, Ala. 36037  
(205) 382-3183

Pettibone Michigan Corp.  
Box 368  
Baraga, Mich. 49908  
(906) 353-6611

Washington Industrial Resources, Inc.  
12514 Pacific Highway South  
Seattle, Wash. 98168  
(206) 244-9510

#### Rotobeater:

Bennington Tractor Corp.  
706 Alpha Dr.  
Cleveland, Ohio 44143  
(216) 499-5816

NFI, Inc.  
6407 Masonic Dr.  
Alexandria, La. 71301  
(318) 487-8371

Pettibone Michigan Corp.  
Box 368  
Baraga, Mich. 49908  
(906) 353-6611

Royer Foundry and Machine Co.  
Box 1232  
158 Pringle St.  
Kingston, Pa. 18704  
(717) 287-9624

#### For additional information refer to:

McKenzie, D. W. and M. Miller. 1978. Field equipment for precommercial thinning and slash treatment. USDA Forest Serv. SEDDC ED&T 2608, 81 p., San Dimas, Calif.

# Handtools

## Function

A variety of handtools may be adapted for brush control. These methods are very labor intensive and best suited to small, remote areas or very sparse stands.

## Description

Common handtools such as chain saws, brush cutters, crosscut saws, pruning saws, pruning shears, hand clippers, brush hooks, axes, pulaskis, and shovels have been used for limited brush control. These tools are easily obtained.

## Techniques

Brush may be cut, pruned, or grubbed to remove the plants or control their growth.

## Capabilities

Handtools may treat practically any terrain. They are easily transported to remote areas and can control very small or sparse stands of brush. Hand treatments may effectively increase browse availability for wildlife habitat improvement.

## Limitations

Handtools cannot effectively treat sprouting shrubs. Hand treatments are very labor intensive and may prove too expensive. Powered handtools, such as chain saws or brush cutters, are not permitted in wilderness areas.



*Pruning saw.*



*Hand clipper.*



*Chain saw.*



*Crosscut saw.*

*Handtools for controlling brush.*



*Pulaski.*



*Brush hook.*



*Brush blade.*



*Pruning shears.*



*Double bit ax.*



*Shovel.*

*Handtools for controlling brush.*

## Specifications

### Chain saws:

Bar length 10 to 32 in (24 to 81 cm)  
Weight 9.5 to 22 lb (4.3 to 10 kg)  
Power ratings 2.5 to 9 hp (1.9 to 6.8 kW)

### Brush cutters:

Blade diameter to 11 in (28 cm)  
Overall length to 5 ft 10 in (1.8 m)  
Weight 16 to 29 lb (7.3 to 9.2 kg)  
Power ratings 3 to 4.5 hp (2.2 to 3.4 kW)

### Crosscut saws:

Length 3 to 8 ft (.9 to 2.4 m)  
Weight 3.5 to 8 lb (1.6 to 3.6 kg)

### Pruning saws:

Blade length 10 to 25 in (25 to 61 cm)  
Handle length:  
    to 10 ft (3 m)  
    to 16 ft (4.9 m) extended  
Weight 1 to 11 lb (.5 to 5 kg)

### Pruning shears:

Blade length 1 to 11 in (2.5 to 27.9 cm)  
Overall length 6 to 37 in (15 to 94 cm)  
Weight .8 to 4 lb (.4 to 1.8 kg)

### Hand clippers:

Blade length to 4 in (10 cm)  
Handle length 19.5 to 35 in (50 to 89 cm)  
Weight 3.1 to 7 lb (1 to 3.2 kg)

### Brush hooks:

Blade length 9 to 16 in (23 to 41 cm)  
Handle length 9 to 42 in (23 to 107 cm)  
Weight 2.9 to 5.5 lb (1.3 to 2.5 kg)

### Axes:

Blade length 4 to 8 in (10 to 20 cm)  
Handle length 12 to 36 in (30 to 91 cm)  
Weight 1.5 to 6 lb (.7 to 2.7 kg)

### Pulaskis:

Blade length 4.5 in (10 to 11 cm)  
Handle length 36 in (30 cm)  
Weight 5 lb (2.2 kg)

### Shovels:

Blade length 9 to 12 in (23 to 30 cm)  
Handle length 27 to 48 in (69 to 122 cm)  
Weight 2.5 to 5 lb (1.1 to 2.3 kg)

## Availability

Handtools are available from manufacturers or suppliers of farm, ranch, or forestry equipment. Most handtools also may be obtained through Federal GSA depots.

## Controlling Plants with Chemicals

This section deals with equipment for chemical control of undesirable vegetation. Some of the equipment may also apply fertilizer. Equipment adapted for the distribution of granules or pellets, such as fertilizer spreaders, granular applicators, seed broadcasters, or drill attachments, is included in the *Fertilizing and Mulching or Seeding* sections.

Many different types, formulations, or concentrations of herbicides are available for rangeland treatment. The rates and times of application can be manipulated to obtain the desired degree of control. Chemical treatments may be combined with mechanical maintenance or burning treatments. Herbicide treatments are usually intended to release desirable plant growth, although areas are sometimes seeded or planted following chemical applications. Chemical treatments are generally less expensive than mechanical control, but may be more expensive than burning.

To be effective, chemical applications must be timed to coincide with the most vulnerable stages of plant development. Herbicides either are translocated to a vulnerable area within the plant or kill plant tissues on

contact. They may be selective or nonselective. The herbicides most common for range improvement (2,4-D; 2,4,5-T; silvex; dicamba; and picloram) are all translocated and selective. They have a mild to moderate toxicity. At normally prescribed rates, these chemicals have little effect on desirable grasses. The remaining grass and litter helps prevent erosion on treated areas. Because herbicides are persistent, livestock grazing is deferred from several days to a few years following application.

Herbicides may be sprayed over foliage, poured around individual stems, broadcast over the ground, or injected into the soil. When properly applied, they are safe and effective. However, users must be extremely careful to prevent contamination of water supplies, destruction of farm crops, and other undesirable impacts. Instructions printed on container labels should always be carefully followed and all regulations or policies concerning chemical applications should be observed. Proper storage, handling, and disposal of these chemicals and their containers is essential. Careless or indiscriminate use of herbicides is dangerous.

### Fixed-Wing Aircraft Sprayers

#### Function

Airplanes, equipped with boom sprayers along the wings, control brush on large areas. Areas that are inaccessible to ground equipment can be treated easily.

#### Description

Monoplanes and biplanes are equipped with boom sprayers mounted along or near the lower wing. Diaphragm check nozzles over .125 in (3.1 mm) in diameter are used. They should be directed with the slipstream, a maximum of 10° downward to minimize drift. The nozzles should not be located within 3 ft (.9 m) of the wingtips because the turbulent wingtip vortices cause drift. The sprayers must have positive cut-off valves and diaphragm check nozzles to avoid continuous spraying during turns or over areas not to be treated. Special pumps avoid pressure build-up when the cut-off valves are closed.

#### Techniques

Spraying techniques are aimed at minimizing drift and maintaining droplet size and uniformity. This increases the penetration and absorption of the foliage sprays. The sprays should be released as low as possible over the area. Discharge pressures should be under 35 lb/in<sup>2</sup> (241 kPa). Spraying should be done on calm, warm, and humid days, preferably during the early morning or late evening. These conditions provide an ideal combination of minimum air movement, low evaporation potential, and high plant susceptibility. Chemical formulations (herbicides mixed with carriers and surfactants) should be developed for high specific gravity, low volatility, and maximum adhesion. Exercise special care in areas near susceptible crops. Markers or spotters are necessary to identify spray area boundaries and areas previously covered. Application rates range from 1 to 5 gallons per acre (9.4 to 46.8 l/ha). They are mainly determined by airspeed and altitude.

## Capabilities

Airplanes can spray large areas quickly and effectively. They have larger payload capacities and greater airspeeds than helicopters. Aircraft can effectively treat tall, dense brush stands without mechanical disturbance. Inaccessible areas can be reached easily using aircraft.

## Limitations

Planes require airstrips for takeoff and landing. Long shuttle distances between the airstrip and the spray area waste time. Trees, powerlines, and rugged terrain are potential hazards for low flying aircraft.



*Belly tank sprayer for a fixed-wing aircraft.*



*Fixed-wing aircraft sprayer.*

## Specifications

Payload 68 to 1,165 gal (310 to 5,296 l)  
Speed 75 to 174 mph (120 to 280 km/hr)  
Power ratings 150 to 2,100 hp (112 to 1,566 kW)

## Availability

### Contractors:

Aerial application contractors operate from many local airports.

### Equipment:

Agrinautics  
Box 11045  
1333 Patrick Lane  
Las Vegas, Nev. 89111  
(702) 736-3794

Amchem Products, Inc.  
Brookside Ave.  
Ambler, Pa. 19002  
(215) 628-1225

Simplex Manufacturing Co.  
5224 Northeast 42nd Ave.  
Portland, Oreg. 97218  
(503) 281-0039

Sorensen Sprayers, Inc.  
Box 344  
Worthington, Minn. 56187  
(507) 376-6230

Transland, Inc.  
24511 Frampton Ave.  
Harbor City, Calif. 90710  
(213) 534-2511

# Helicopter Boom Sprayers

## Function

Helicopters with boom sprayers are well suited for spraying large, remote areas or steep, rough terrain. They are especially useful in situations where precise spray applications are required.

## Description

Booms up to 40 ft (12.2 m) long are attached to the helicopters. Hydraulic nozzles are spaced along the entire length. The number of nozzles is determined by the swath width and the application rate. The minimum nozzle diameter is .125 in (3.2 mm).

Lightweight tanks, special pumps, and positive shut-off valves are included in the spray system. Payloads are carefully determined before spray operations.

## Techniques

Helicopter operators maintain a constant speed of about 45 mph (72.4 km/hr). Low altitude operation prevents excessive drift; but trees, power lines, or terrain features may require operation at higher altitudes. Discharge pressures vary from 30 to 40 lb/in<sup>2</sup> (207 to 276 kpa) and application rates vary from 4 to 7.5 gal/acre (37.4 to 70.1 l/ha).



*Helicopter boom sprayer with side tanks.*

Ideally, spraying should be done on calm, warm, and humid days, during the morning or evening hours. In areas close to vulnerable crops, a slight sustained breeze away from the crops is desirable. Spotters or markers are necessary to direct spray applications.

## Capabilities

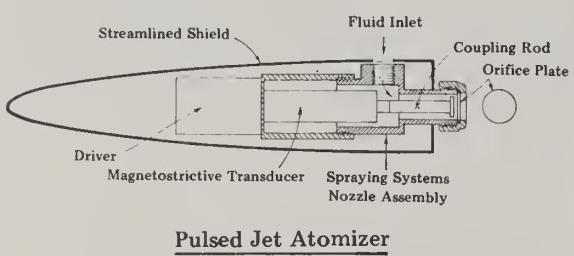
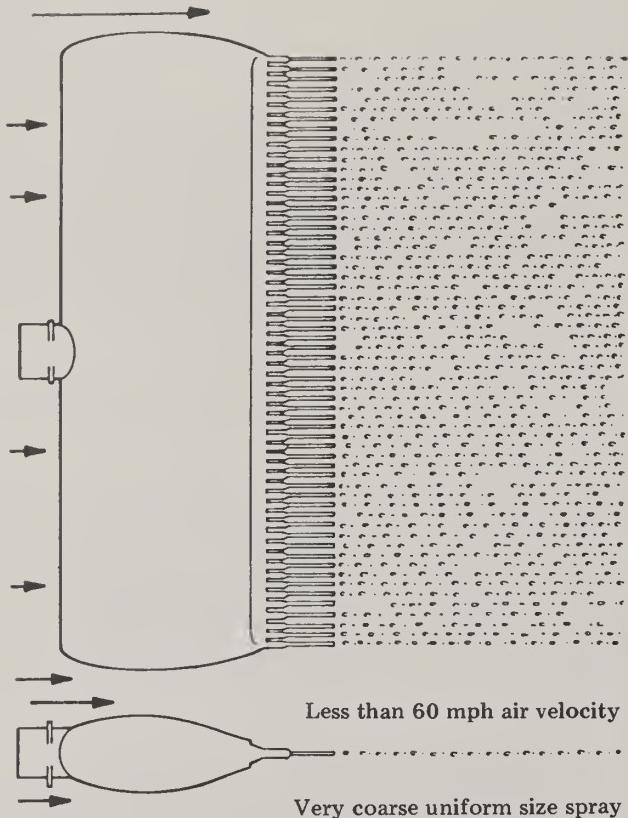
Helicopters are well suited for treating remote areas because they do not require airstrips for takeoff and landing. They are adapted to steep, rough terrain and often treat mountain areas. Slower airspeeds and greater maneuverability allow more precise control of herbicide applications with helicopters than with fixed-wing aircraft. The land is treated without mechanical disturbance.

## Limitations

Small payload capacities require frequent refilling stops at the mixer truck. The slower airspeeds of helicopters contribute to lower production rates than with fixed-wing aircraft.



*Helicopter-mounted belly tank sprayer.*



*Microfoil spray boom designed to create large uniform spray droplets.*

#### Specifications

Payload 34 to 352 gal (164 to 1,600 l)  
 Airspeed 40 to 50 mph (64.4 to 80.5 km/hr)  
 Power ratings 180 to 1,700 hp (139 to 1,268 kW)

## Availability

### Contractors:

Aerial application contractors operate from many local airports.

### Equipment:

Agrinautics  
Box 11045  
1333 Patrick Lane  
Las Vegas, Nev. 89111  
(702) 736-3794

Amchem Products, Inc.  
Brookside Ave.  
Ambler, Pa. 19002  
(215) 628-1000

Campbell Air Services, Inc.  
Box 872  
Vivian, La. 71082  
(318) 375-3207

Chadwick, Inc.  
11969 Southwest Herman Rd.  
Sherwood, Oreg. 97140  
(503) 638-8511

Rambling Rotors, Inc.  
Box 2744  
Route 2  
LaGrande, Oreg. 97850  
(503) 963-5644

Simplex Manufacturing Co.  
5224 Northeast 42nd Ave.  
Portland, Oreg. 97218  
(503) 281-0039

Sorensen Sprayers, Inc.  
Box 344  
Worthington, Minn. 56187  
(507) 376-6230

Transland, Inc.  
24511 Frampton Ave.  
Harbor City, Calif. 90710  
(213) 534-2511

## Automatic Flagman

### Function

The automatic flagman marks spray areas from the air. The device drops weighted streamers directly from the spray aircraft.

### Description

The automatic flagman is a rectangular dispenser that holds up to 280 markers. The markers are 15 or 16 ft (4.6 or 4.9 m) paper streamers with weights attached on one or both ends, or in the center. The streamers are available in white or fluorescent orange. They are released one at a time by a solenoid controlled by the pilot. The automatic flagman is approved by the FAA.

### Techniques

The dispenser is mounted near the fuselage. The streamers are released at intervals to mark the center of the spray swath. They are easily seen from the air so the pilot is guided to the next swath after completing a turn or returning from a refilling trip. Streamers may also mark spray area boundaries.

### Capabilities

Most pilots quickly learn to operate the automatic flagman and find it useful in locating spray area boundaries and areas treated during the previous pass. Less manpower is required because the need for spotters is reduced.

### Limitations

The streamers are sometimes obscured by tall or dense brush. Streamers with weights at both ends are available for marking timber or brush over 5 ft (1.5 m) tall. Long streamers should not be deployed at airspeeds over 125 knots (232 km/hr). Although the streamers are degradable, they should be retrieved for esthetic reasons.



*Loading the automatic flagman.*



*Automatic flagman mounted on an airplane wing.*



*Helicopter dropping flags on spray area.*

#### Specifications

Dispenser capacity:

100 streamers for helicopters

180 or 280 streamers for fixed-wing aircraft

Solenoid 12 or 24 volt

Streamer length 15 or 16 ft (4.6 or 4.9 m)

#### Availability

North American Industries, Inc.  
Route 4, City-County Airport  
Walla Walla, Wash. 99362  
(509) 525-4190

# Signal Mirrors

## Function

Signal mirrors can direct aircraft to distant points. They may increase the precision of aerial treatment, especially over very long swaths where the pilot cannot see the end marker or spotter.



## Description

Signal mirrors are double-sided, hand-held mirrors with a small hole in the center.

## Techniques

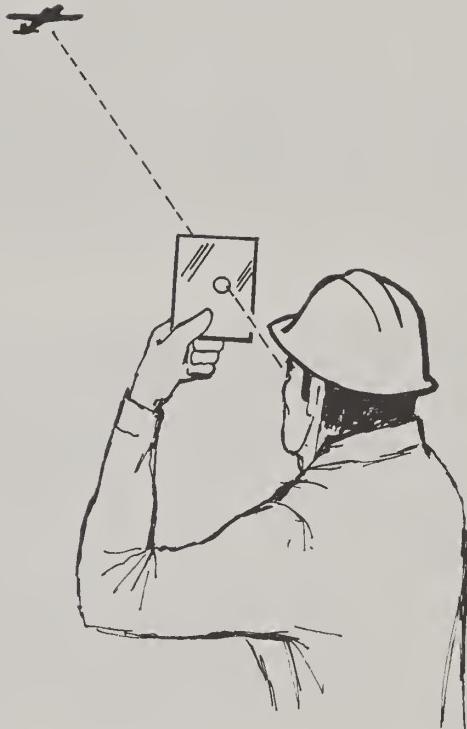
The spotter holds the mirror up and, looking through the center hole, spots the aircraft. The reflection of the small spot of light from the center hole is then aligned with the hole. When the aircraft and the spot reflection are simultaneously aligned in the center hole, the mirror is at the proper angle to reflect the sunlight toward the pilot.

## Capabilities

Pilots are able to home-in on light reflected from a signal mirror. Mirrors allow spotters to more accurately direct aerial seeding or spraying operations, particularly during long passes.

## Limitations

Signal mirrors need bright sunlight to operate effectively. They cannot be used under cloudy conditions.



*Signaling aircraft with a mirror.*

### Specifications

Length 4 to 6 in (10.2 to 15.2 cm)  
Width 3 to 4 in (7.6 to 10.2 cm)  
Center hole diameter approximately 1/8 in (3 mm)

### Availability

Federal stock number 6350-00-261-9772  
Signal mirrors are available from most sporting goods stores.

# Boom Sprayers

## Function

Boom sprayers, mounted on trucks, tractors, or trailers, spray small areas that are relatively accessible. They allow very precise control of spray applications. Spring-loaded, single-point mounted booms have been developed specially for rough rangeland conditions. They are usually mounted on crawler tractors.

## Description

Boom sprayer systems may be mounted on skids that are placed in pickup truck beds, on rubber tire or crawler tractors, on trailers, or on self-propelled or high-flotation chassis. The boom sprayer systems consist of tanks for the spray solution, pumps, pressure gages, booms, and several spray nozzles spaced along the lengths of the booms.

Stainless steel, fiberglass, or plastic tanks are available in various shapes and sizes. Pumps may be of the gear, piston, diaphragm, or centrifugal type. They are powered hydraulically, with power-take-off attachments, or by separate gasoline engines. Pressure gages monitor the discharge pressure that, along with vehicle speed, determines the application rate. The booms can sometimes be raised or lowered to obtain the necessary ground clearance, and may be folded for transport. Long booms are often supported by wheels. Short, spring-loaded, single-point mounted booms have been developed that yield up to 90° when obstructions are encountered. These booms are mounted on crawler tractors or trailers and effectively treat steep, rough terrain. Nozzles are available that distribute the spray in a variety of patterns, such as fan-shaped, solid cone-shaped, or hollow cone-shaped.

## Techniques

Boom sprayers are simply passed over the area to be treated. Spotters or marking devices can insure complete coverage. Application rates usually vary from 10 to 20 gal/acre (94 to 187 l/ha) and sometimes range as high as 50 gal/acre (476 l/ha). Production rates vary considerably. High flotation sprayers are capable of up to 190 acres (77 ha) per hour on cropland. Ground spray applications are generally less expensive than aerial treatments for areas less than 200 acres (80 ha).

## Capabilities

Boom sprayers give even applications of spray with very little drift, which insures uniform coverage. Boom sprayers mounted on crawler tractors are well adapted to rough terrain and steep slopes. The spring-loaded, single-point mounted booms yield easily without snagging on brush. High flotation applicators can be used on soft ground. They are well suited for large areas with gentle terrain.

## Limitations

Boom sprayers are sometimes awkward to maneuver. Tall brush may be difficult to treat effectively. Many boom sprayers are limited to flat, level terrain. Large areas may be better suited to aerial herbicide applications.



*Skid-mounted boom sprayer.*



*Boom sprayer assembly mounted on a three-point hitch.*



*Side-mounted tanks for spraying in front of tillage implements.*



*Trailer-mounted boom sprayer.*



*Side-mounted spray tanks on a small crawler tractor.*



*Single-point mountain spray booms attached to a crawler tractor.*



*Large high flotation boom sprayer.*

## Specifications

### Skid-mounted (pickup truck):

Boom length 27 to 47 ft (8.2 to 14.3 m)  
Tank capacity 100 to 500 gal (379 to 1,893 l)  
Pump capacity 10 to 175 gal/min (38 to 662 l/min)  
Discharge pressure to 500 lb/in<sup>2</sup> (3,447 kPa)  
Power ratings 3 to 8 hp (2.2 to 6 kW)

### Trailer-mounted:

Boom length 27 to 60 ft (8.2 to 18.3 m)  
Tank capacity 100 to 1,000 gal (379 to 3,785 l)  
Pump capacity 10 to 175 gal/min (38 to 662 l/min)  
Discharge pressure to 500 lb/in<sup>2</sup> (3,447 kPa)

### Tractor-mounted:

Boom length 10 to 47 ft (3 to 14.1 m)  
Tank capacity 24 to 500 gal (91 to 1,893 l)  
Pump capacity 6 to 60 gal/min (22 to 227 l/min)  
Discharge pressure to 500 lb/in<sup>2</sup> (3,447 kPa)

### Self-propelled and high flotation:

Boom length 40 to 60 ft (12 to 18 m)  
Tank capacity 320 to 2,800 gal (1.2 to 10.6 kl)  
Pump capacity 17 to 280 gal/min (64 to 1,060 l/min)  
Discharge pressure to 400 lb/in<sup>2</sup> (2,758 kPa)  
Power ratings 62 to 350 hp (46 to 261 kW)

## Availability

### Skid-mounted:

Ag-Chem Equipment Co., Inc.  
4900 Viking Dr.  
Minneapolis, Minn. 55435  
(612) 835-2476

Century Engineering Corp.  
221 Fourth Ave. SE  
Cedar Rapids, Iowa 52401  
(319) 362-4101

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Fargo Foundry Steel and  
Manufacturing Co.  
92 NP Ave.  
Fargo, N.Dak. 58102  
(701) 232-8831

Farnum Equipment Co.  
Box 21447  
Phoenix, Ariz. 85036  
(602) 244-8261

Fimco, Inc.  
First and Court St.  
Sioux City, Iowa 51101  
(712) 258-0171

Hanson Equipment Co.  
301 Charles Ave.  
South Beloit, Ill. 61080  
(815) 389-2261

Larson Machine, Inc.  
Box 308  
Princeville, Ill. 61559  
(309) 385-4312

### F. E. Myers and Brothers Co.

400 Orange St.  
Ashland, Ohio 44085  
(419) 322-1544

United Farm Tools, Inc.  
Box 9175  
South Charleston, W.Va. 25309  
(304) 768-8221

### Rubber-tired tractor and trailer - mounted:

Boom sprayers that are mounted on rubber-tired tractors or trailers are available from most manufacturers of spray equipment, several farm implement manufacturers, and many farm equipment dealers.

### Single-point mounted:

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

Drawings (RM15-01 to 05, RM16-01 to 06, and RM20-01 to 05) and information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

### Self-propelled or high flotation:

Ag-Chem Equipment Co., Inc.  
4900 Viking Dr.  
Minneapolis, Minn. 55435  
(612) 835-2476

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Dempster Industries, Inc.  
Box 848  
Beatrice, Nebr. 68310  
(402) 223-4026

Hahn, Inc.  
1625 North Garvin  
Evansville, Ind. 47711  
(812) 424-0931

John Blue Co.  
Box 1607  
Huntsville, Ala. 35807  
(205) 536-5581

Rickel Manufacturing Corp.  
Box 626  
Salina, Kans. 67401  
(913) 825-1631

Tryco Manufacturing Co., Inc.  
Box 1277  
Decatur, Ill. 62525  
(217) 428-0901

Wilmar Manufacturing Co.  
Box 957  
Wilmar, Minn. 56201  
(612) 235-0767

# Broadjet Sprayers

## Function

Broadjet sprayers are useful for treating areas where long booms become unwieldy. Steep or rough terrain, fencerows, and areas with many obstructions can be treated with broadjet sprayers.

## Description

Broadjet spraying systems are the same as boom systems except that a single nozzle or a cluster of nozzles replace the boom. Broadjet systems often have accessory hoses mounted on reels for spot treatments.

## Techniques

Broadjet sprayers distribute the spray in a wide, fan-shaped area behind the prime mover. Spotters or markers may mark the swath as the sprayer is moved over an area. The swaths are often overlapped to insure complete coverage. Application rates vary from 20 to 50 gal per acre (187 to 467 l/ha). Hoses can be used for spot treatments away from the prime mover.

## Capabilities

Broadjet sprayers are easy to maneuver in areas with rough terrain or many obstacles. They can treat areas with tall, dense brush cover. Broadjet spray nozzles are less likely to clog than the smaller boom nozzles.

## Limitations

Spray distribution with broadjet sprayers is less uniform than with boom sprayers. Great precision is not obtained because the wide spray swath is subject to more drift and evaporation. Government regulations may restrict or prohibit broadjet spraying in certain locations.



*Skid-mounted broadjet sprayer.*

## Specifications

Swath width to 40 ft (12.2 m)  
Tank capacities to 350 gal (1,325 l)  
Pump capacities to 175 gal/min (662 l/min)  
Discharge pressure to 400 lb/in<sup>2</sup> (2,758 kPa)

## Availability

### Tractor- or trailer-mounted:

The Broyle Co.  
North Market Square  
Dakota City, Nebr. 68731  
(402) 987-3412

Century Engineering Co.  
221 Fourth Ave. SE  
Cedar Rapids, Iowa 52401  
(319) 364-4101

Continental Belton Co.  
Box 660  
Belton, Tex. 76513  
(817) 939-3731

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

FMC Corp.  
Agricultural Machinery Div.  
5601 East Highland Dr.  
Jonesboro, Ark. 72401  
(501) 935-1970

Fargo Foundry Steel & Mfg. Co.  
92 NP Ave.  
Fargo, N.Dak. 58102  
(701) 232-8831

Farnum Equipment Co.  
Box 21447  
Phoenix, Ariz. 95036  
(602) 244-8261

Fimco, Inc.  
First and Court St.  
Sioux City, Iowa 51101  
(712) 258-0171

Hanson Equipment Co.  
301 Charles Ave.  
South Beloit, Ill. 61080  
(815) 389-2261

H. D. Hudson Mfg. Co.  
500 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 644-2830

KBH Corp.  
Box 670  
Clarksdale, Miss. 38614  
(601) 624-5471

Rears Manufacturing Co.  
2140 Prairie Rd.  
Eugene, Oreg. 97402  
(503) 688-1002

Root Lowell Corp., Div.  
1000 Foreman Rd.  
Lowell, Mich. 49331  
(616) 897-9212

Southern Mill Creek  
Products Co., Inc.  
Custom Built Sprayers  
Box 1096  
Tampa, Fla. 33601  
(813) 626-2111

Nozzles and accessories:  
Spraying Systems Co.  
North Ave. at Schmale  
Wheaton, Ill. 60187  
(312) 665-5000

# Mist Sprayers

## Function

Mist sprayers are useful where thorough penetration of heavy cover is required. They can treat tall vegetation from ground level. Mist sprayers are low-volume applicators that use concentrated chemical formulations.

## Description

Mist sprayers have spray nozzles located in the middle of an airstream. The airstream is produced by a powerful fan. The fan may be either bladed or axial. Mist sprayers are available in a variety of sizes, ranging from small portable and backpack models to large trailer-mounted models. They may be powered hydraulically, with power-take-off attachments, or by separate gasoline engines. Diaphragm or piston pumps are preferred to handle thick solutions or powders. Some mist sprayers can also dust.

## Techniques

When the spray is injected into the airstream, a fine, fog-like mist is produced. The mist is directed over an area with various blower outlets. The mist penetrates the foliage and slowly settles on the plant surfaces. Low pressures are necessary to prevent excessive drift and evaporation.

## Capabilities

Mist blowers can treat dense stands of tall brush. The concentrated chemical formulations are distributed over the treated areas at low rates. Swath widths range up to 100 ft (30 m) and enable rapid treatments. Portable or backpack mist sprayers can be used in small, inaccessible areas.



*Controlling weeds with a backpack mist sprayer.*

## Limitations

The fine mist from sprayers is subject to drift and evaporation and mist spraying should be restricted to calm days. Precise control of chemical applications from mist sprayers is difficult. In some areas mist spraying may be restricted or prohibited by law or existing policy.



*Backpack portable mist sprayer.*



*Mist sprayer on a logging skidder.*



*Large mist sprayer that can be mounted on a truck or tractor.*



*Truck-mounted mist sprayer for controlling brush.  
(Automatic Equipment Mfg. Co. photo)*

## Specifications

### Backpack or portable:

Tank capacity .25 to 3.50 gal (.9 to 13.2 l)  
Air volume 390 to 750 cu ft/min (11 to 21 m<sup>3</sup>/min)  
Air velocity 80 to 250 mph (129 to 402 km/hr)  
Discharge rate to 1 gal/min (3.9 l/min)

### Tractor-, truck- or trailer-mounted:

Tank capacity 30 to 400 gal (189 to 1,514 l)  
Air volume 1,200 to 8,500 cu ft/min (241 to 680 m<sup>3</sup>)  
Air velocity to 210 mph (338 km/hr)  
Pump capacity .5 to 10 gal/min (1.9 to 37.9 l/min)

## Availability

### Backpack or portable:

Buffalo Turbine  
Agricultural Equipment Co., Inc.  
Gowanda, N.Y. 14070  
(716) 532-2272

Root Lowell Corp. Div.  
1000 Foreman Rd.  
Lowell, Mich. 49331  
(616) 897-9212

Solo Motors Inc.  
Box 5030  
Newport News, Va. 23605  
(804) 245-4228

Stihl, Inc.  
536 Viking Dr.  
Virginia Beach, Va. 23452  
(804) 486-8444

TSI Co.  
Box 151  
Flanders, N.J. 07836  
(201) 584-3417

Vandermolen Corp.  
119 Dorsa Ave.  
Livingston, N.J. 07039  
(201) 992-8506

### Tractor-, truck- or trailer-mounted:

Automatic Equipment Mfg. Co.  
Box P  
Pender, Nebr. 68047  
(402) 385-3051

Buffalo Turbine  
Agricultural Equipment Co., Inc.  
Gowanda, N.Y. 14070  
(716) 532-2272

FMC Corp.  
Agricultural Equipment Div.  
5601 Highland Dr.  
Jonesboro, Ark. 72401  
(501) 935-1990

Farnum Equipment Co.  
Box 21447  
Phoenix, Ariz. 95036  
(602) 244-8261

Hanson Equipment Co.  
301 Charles Ave.  
South Beloit, Ill. 61080  
(815) 389-2261

F. E. Myers and Brothers Co.  
400 Orange St.  
Ashland, Ohio 44805  
(419) 322-1544

Pettibone Michigan Corp.  
Box 368  
Baraga, Mich. 49908  
(906) 353-6611

Potts Mist Blower  
Box 161  
Crawford, Miss. 38743  
(601) 272-5604

Root Lowell Corp. Div.  
1000 Foreman Rd.  
Lowell, Mich. 49331  
(616) 897-9212

Solo Motors, Inc.  
Box 5030  
Newport News, Va. 23605  
(804) 245-4228

W & A Manufacturing  
Box 5238  
Pine Bluff, Ark. 71611  
(501) 534-7420

## Hand-Operated Sprayers

### Function

Hand-operated sprayers are for spot treatments of individual plants or small stands. They are useful in areas where access is limited.

### Description

Hand-operated sprayers are either pressurized containers, or knapsack types that have small, hand-operated hydraulic pumps. Hand-operated sprayers have cut-off valves located on the handles. A hose links the handle to the tank. Hand-operated sprayers may have a single, long nozzle or a small boom containing up to four nozzles.

### Techniques

The pressurized herbicide container is carried with a shoulder strap and operated by squeezing the cut-off valve. Pressure is supplied by operating the plunger pump. The knapsack pump is operated by working a lever at the side of the tank while the cut-off valve is

held open. Various mechanisms regulate the pressure at the desired level to reduce pulsation.

The operator walks through the area treating individual plants or small stands. The spray is directed with the long nozzle or short boom held close to the plant being treated.

### Capabilities

Hand-operated sprayers permit selective plant control on limited areas. Complete coverage of individual plants insures kills while nearby plants remain unaffected. Hand-operated sprayers can apply a wide variety of solutions including liquid fertilizers and repellents.

### Limitations

Hand-operated sprayers are limited to very small areas. Because of their small capacities, these portable units may require frequent refilling. Adequate pressure must be maintained for reliable operation.



*Portable compressed air sprayer.*



*Backpack sprayer.*

## Specifications

### Pressurized containers:

Capacity to 18 gal (68 l)  
Pump-type plunger  
Operating pressure 25 to 50 lb/in<sup>2</sup>  
(172 to 345 kPa)

### Knapsack sprayers:

Capacity 4 to 6 gal (15.1 to 22.7 l)  
Pump-type piston, diaphragm, or double acting slide  
Operating pressure to 150 lb/in<sup>2</sup> (1,034 kPa)

## Availability

R. E. Chapin Manufacturing Works, Inc.  
29 Liberty St.  
Batavia, N.Y. 14020  
(716) 343-3140

H. D. Hudson Manufacturing Co.  
500 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 644-2830

Root Lowell Corp. Div.  
1000 Foreman Rd.  
Lowell, Mich. 49331  
(616) 897-9212

D. B. Smith and Co.  
414 Main St.  
Utica, N.Y. 13503  
(315) 735-5223

Solo Motors, Inc.  
Box 5030  
Newport News, Va. 23605  
(804) 245-4228

TSI Co.  
Box 151  
Flanders, N.J. 07836  
(201) 584-3417

Vandermolen Corp.  
119 Dorsa Ave.  
Livingston, N.J. 07039  
(201) 992-8506

## Techniques

The spinning disk atomizer produces droplets of uniform size (70 to 250 microns, depending on the model used). This allows the use of concentrated herbicide formulations because problems with evaporation of small droplets (as little as 5 microns) and runoff of large droplets (up to 700 microns) are eliminated. Only 5 percent of the water that is needed in other spray system formulations is required. The applicator can be held close to the ground for minimum drift or held high for controlled drift applications.

## Capabilities

Ultra-low-volume applicators are lightweight, simple to use, and easy to maintain. The spinning disk atomizer is more efficient because it eliminates most of the water in the formulations.

## Limitations

The batteries permit only 4 to 6 hours of operation before they must be changed. They give 15 to 20 hours of total spraying time. For larger projects, rechargeable batteries should be considered. Operators should wear protective clothing.

## Ultra-Low-Volume Applicators

### Function

Ultra-low-volume applicators have been developed for treating small areas and individual plants. They have treated dense brush in inaccessible areas.

### Description

Ultra-low-volume applicators rely on batteries to power a spinning disk atomizer. The batteries are either held in a plastic tube that also serves as a handle, or attached to the end of the handle. The disks are powered by a constant-speed electric motor and the disks are grooved and toothed to produce a uniform droplet size.

The herbicide formulation is gravity fed through a nozzle to the atomizer. Nozzles are available with varying flow rates for different herbicide formulations. Application rates vary from .2 to 1.1 gal per acre (1.6 to 10.3 l/ha).



*Low-volume applicator for treating large areas by hand.*



*Low-volume applicator for selective treatment of small areas.*

### Specifications

Capacity 1.1 to 2.6 qt (1 to 2.5 l) bottles  
refilled from 5.3 qt (5 l) knapsacks  
Droplet diameter .003 or .010 in (70 to 250 microns)  
Flow rates 1 to 6.1 fluid oz/min (30 to 180 ml/min)  
Power supply 12V, 7W electric motors

### Availability

Micron Sprayers, Ltd.  
Three Mills  
Bromyard, Herefordshire, HR7 4HU  
England

Micron West, Inc.  
8582 Katy Freeway  
Houston, Tex. 77024  
(713) 932-1405

Turbair, Ltd.  
Britannica Works  
Waltham Abbey, Essex, ENP 1NP  
England

## Subsoil Injectors

### Function

Subsoil injectors place liquid fertilizer, sewage sludge, or herbicides directly into the soil. The material may be absorbed directly by plant roots or acted upon by soil micro-organisms.

### Description

Subsoil injectors consist of a tank for the liquid, a pump, and soil penetrating devices. The liquid is injected by tubes attached behind the soil penetrating devices. Flexible hoses connect the injector tubes to pump. Subsoil injector systems may be mounted on trailers, trucks, or high flotation equipment.

### Techniques

The soil penetrating devices with the injectors are pulled through the soil at the desired depth. The furrow opening closes immediately behind the penetrating devices to prevent evaporation, so the amendments are locked in the soil where they are absorbed.

### Capabilities

Subsoil injectors incorporate liquid fertilizer, sewage sludge, or herbicide into the soil. The materials do not require rainfall for infiltration and percolation and they cannot be removed by surface winds or runoff.

### Limitations

Soil injection is a very intensive treatment that is usually limited to agricultural land. Because tillage is involved, rocky land and rough terrain cannot be treated easily.



*Subsoil chemical injector.*



*Sludge injector.*

### Specifications

|   |
|---|
| Width 8 ft 8 in to 11 ft (2.6 to 3.4 m) |
| Depth to 12 in (30 cm)                  |
| Tank capacity to 3,600 gal (13.6 kl)    |

### Availability

Ag-Chem Equipment Co., Inc.  
4900 Viking Dr.  
Minneapolis, Minn. 55935  
(612) 835-2476

Big Wheels, Inc.  
Box 113  
Paxton, Ill. 60957  
(217) 379-2369

The Calumet Co.  
340 North Water St.  
Algoma, Wis. 54201  
(414) 487-5251

Dempster Industries, Inc.  
Box 848  
Beatrice, Nebr. 68310  
(402) 223-4026

John Blue Co.  
Box 1607  
Huntsville, Ala. 35807  
(205) 536-5581

KBH Corp.  
Box 670  
Clarksdale, Miss. 38614  
(601) 624-5471

Tryco Manufacturing Co.  
Box 1277  
Decatur, Ill. 62525  
(217) 428-0901

Tyler Div.  
TCI, Inc.  
Benson, Minn. 56215  
(612) 843-3333

## Tree Injectors

### Function

Tree injectors can treat individual trees or shrubs. Herbicide is injected directly into the tree or into the surrounding soil.

### Description

Conventional tree injectors are long, hollow tubes with a cutting bit on one end. The tube is filled with a herbicide formulation. A hatchet injector, or hypo-hatchet, has a plastic feeder tube connected to the hatchet handle. The tube supplies herbicide to the hatchet from a container attached to the operator's belt. A special bit injects the herbicide into the tree when it is struck. An average of 1 milliliter is delivered after each impact.

### Techniques

Conventional injectors are thrust into the base of the tree or into the surrounding soil. The bit creates a pocket into which herbicide is released. The herbicide moves throughout the tree, eventually killing it.

The hypo-hatchet cuts into the tree, injecting the herbicide. One injection for each inch (2.5 cm) of diameter is recommended. The hypo-hatchet is most effective at waist height because the bark is thinner and easier to penetrate than at the base.

### Capabilities

Tree injectors selectively kill individual trees or brush plants. They are useful for thinning stands or for controlling very sparse stands. They are portable and easy to use in remote areas.

### Limitations

Removal of trees or brush killed by injection may be a problem. The hypo-hatchet is only useful on fairly large trees. All tree injectors should be handled carefully to minimize contact with the herbicide.

#### Availability

Conventional tree injectors:

Ben Meadows Co.  
3589 Broad St.  
Atlanta, Ga. 30366  
(404) 455-0907

Dan Little Tree Injector, Co.  
Box 278

Madill, Okla. 73446  
(405) 795-3123

Forestry Suppliers, Inc.  
Box 8397  
Jackson, Miss. 39204  
(601) 354-3565



*Hypo-hatchet tree injector.*



*Conventional tree injector.*

### Specifications

#### Conventional tree injectors:

Length 48 to 56 in (121 to 142 cm)  
Weight 11 to 12 lb (5 to 5.4 kg) empty  
Capacity 2.5 to 4 quarts (2.4 to 3.8 l)

#### Hypo-hatchet:

Weight 3.5 lb (1.6 kg)  
Capacity 1 qt (.9 l)

#### Hypo-hatchet:

|  |  |
|--|--|
| Panama Pump Co.<br>Box 689<br>Hattiesburg, Miss. 39402<br>(601) 544-4251 | TSI Co.<br>Box 151<br>Flanders, N.J. 07836<br>(201) 584-3417 |
|--|--|

## Controlling Plants with Heat

The equipment in this section is primarily for controlling or managing vegetation with heat, mostly in the form of fire. This section includes equipment for fire ignition. Some of the equipment from the sections on mechanical and chemical control may also control fires.

Fire is an ancient and effective method of manipulating vegetation. Fire should always be carefully prescribed. The time and intensity of burning treatments can be varied to achieve specific management objectives. Fires are often combined with mechanical or chemical control methods as part of an overall range improvement plan.

Fire is often the least expensive means of vegetative control. It requires only sufficient ground fuel and suitable weather conditions. Under ideal conditions it

can give rapid and uniform treatment of fairly large areas regardless of slope, soil, or terrain limitations. However, burning treatments may be spotty in areas with low fuel loads and the erosion hazard is increased on burned lands. Forage production, palatability, and availability are usually improved following a burn. Seed may be planted or broadcast over burned areas.

Prescribed burns should include careful preparation and efficient execution to maintain control. Land managers should precisely define area boundaries, construct adequate firebreaks, and prepare the fuel prior to burning. Weather conditions should be carefully monitored before and during the burn. Sufficient fire suppression equipment and personnel should be available to extinguish the fire, should it become necessary. Responsible and experienced judgment is invaluable when handling prescribed burns.

### Incendiary Grenade Launcher

#### Function

The incendiary grenade launcher provides a safe, easy method of aerial ignition for wildfire control and prescribed burns. It has been used successfully for igniting burnouts within wildfire control lines and for browse burning on big game range early in the season. The incendiary grenade launcher can be appropriate in many situations where ground ignition is difficult.

#### Description

The incendiary grenade launcher is a military grenade dispenser adapted to small helicopters. The XM-118 dispenser is attached to a special mounting bracket with an MA-4 aircraft bomb rack. This allows the dispenser and grenades to be jettisoned by the pilot in an emergency. The grenade launcher controls are operated by the pilot or a firing specialist, who accompanies the pilot in the helicopter. Each dispenser holds 12 grenades. Military AN-M14 thermite grenades provide the best ignition.

#### Techniques

The grenades are loaded in the dispenser, which is then attached to the helicopter. The grenades are released over suitable ignition points. Grenades can be released from a higher altitude than other aerial ignition devices for an additional margin of safety.

#### Capabilities

Multiple-point ignition is achieved quickly and easily with the incendiary grenade launcher. Fires can be ignited from the air on areas where ground ignition would be difficult or hazardous.

#### Limitations

Safety must be continually stressed. Three- to five-person firing crews should be thoroughly trained in aerial ignition principles and techniques. FAA approval must be obtained for mounting incendiary grenade launchers on helicopters. Thermite grenades are expensive and difficult to obtain. The launcher also requires frequent reloading.



Incendiary grenade launcher mounted on a helicopter.

## Specifications

Capacity 24 or 48 grenades  
Mounting brackets and controls have been designed for many light helicopters.

## Availability

Drawings (No. 522) and information are available from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

# Ping-Pong Ball Injectors

## Function

Ping-pong ball injectors were designed to provide rapid, low-cost multiple-point ignition for prescribed burning and for backfiring or burnout on wildfires. The ignition of large areas can be accomplished during a short time when burning conditions are favorable.

## Description

Ping-pong balls loaded from 3 to 4.5 g of potassium permanganate ( $KMnO_4$ ) are mechanically injected with ethylene glycol and dropped along the area of ignition. The chemical reaction produces a small flame and sufficient heat to ignite dry vegetation. Helicopter-mounted mechanisms automatically inject the ping-pong balls with ethylene glycol and eject them at rates up to four per second.

One mechanism consists of a hopper, two rotating cut-out disks, a needle, an ejector arm, and a pressurized tank for the ethylene glycol. The ping-pong balls drop into spaces cut in the rotating disks. The needle located between the disks penetrates each ball as the disks revolve.

The ball is then forced out of an opening in the hopper magazine by the ejector arm. An air cylinder maintains the pressure in the ethylene glycol tank.

An improved machine has four slipper blocks that move back and forth between the four feed chutes and the ejection chute. The balls drop into the slipper blocks on the forward stroke. A needle with a spring-loaded valve is located at the end of the forward stroke to inject the ethylene glycol. The ejection chute is positioned at the end of the backstroke. A chain-driven camshaft provides the necessary range of motion. The feed chutes can be blocked to control the rate that the incendiaries are released.

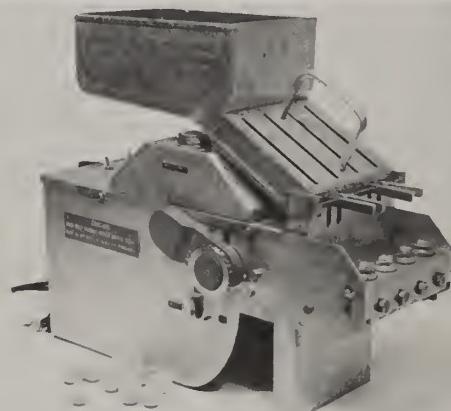
The ping-pong ball injectors are electrically powered and can be controlled by the pilot. They are mounted in the helicopter door to enable the pilot to jettison the load if necessary.

## Techniques

The helicopter flies over the area at an altitude of 100 to 300 ft (30 to 91 m). At an airspeed of 45 mph (72 km/hr), the incendiaries are placed about 13.5 ft (4.1 m) apart. By varying the airspeed and release rate, the distance can be varied from 3.3 to 72.2 ft (1 to 22 m).

## Capabilities

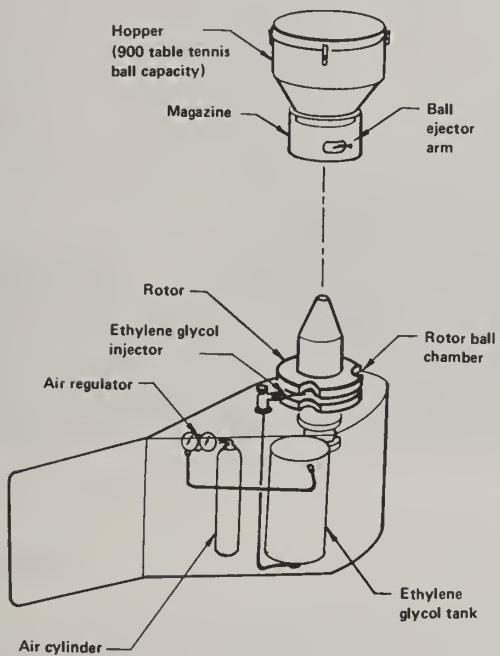
The ping-pong ball injector is a safe, reliable device for multiple-point aerial ignition. It can effectively treat large scale prescribed burns where other ignition methods prove unreliable or uneconomical.



Slipper block incendiary ball dispenser.

## Limitations

Since the potassium permanganate and ethylene glycol reaction is less intense than thermite grenades, fuel loads should be sufficiently dry, heavy, and uniform to carry the fire. FAA approval is required for mounting ping-pong ball injectors on helicopters.



*Revolving disk ping-pong ball injector.*

## Specifications

Capacity 350 to 900 balls  
Discharge rate to 4 balls per second  
Ground spacing 3.3 to 72.2 ft  
(1 to 22 m) approximately 13.5 ft  
(4.1 m) at 45 mph (72 km/hr)  
Power supply 24 V (DC) electrical system

## Availability

Revolving disk type:

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

Slipper block type:

Premo Plastics Engineering, Ltd.  
863 Viewfield Rd.  
Victoria, B.C., Canada V9A 4V2  
(604) 382-3023

Information may be obtained from:

Environment Canada  
Canadian Forestry Service  
Pacific Forest Research Centre  
506 West Burnside Rd.  
Victoria, B.C., Canada V8Z 1M5  
(604) 388-3811

## Fusee Dispenser

### Function

A fusee dispenser has been developed for easy, inexpensive aerial ignition. The fusee flares are ignited as they drop from the dispenser and burn for 10 minutes, assuring adequate ignition. The dispenser is being tried for backfiring projects in Alaska. It may prove to be an economical alternative for aerial ignition of range-lands.

### Description

The fusee dispenser is a revolving carousel with 16 cylinders that rotate over an ignition chamber. The device is hand-operated with a lever or ratchet handle, although a spring-loaded, cable-released rotation mechanism is available. Three 10-minute flares are stacked into each cylinder. They are gravity-fed into the ignition chamber when the cylinder is positioned over it. A special bridge-wire cap on each flare provides contact between the prime button of the flare and the electrical ignition brushes in the ignition chamber. The 24-volt, 240-amp ignition system draws power from special gel-celled batteries or from the aircraft electrical system equipped with slow-blow fuses to withstand temporary overloads. The fusee dispenser can be adapted to both fixed-wing aircraft and helicopters.

### Techniques

The carousel is loaded and controlled from the aircraft. As the flares drop into the ignition chamber, the bridge-wire cap provides an interference fit between the brushes, which stops the flare momentarily and allows the bridgewire to heat. The heated bridgewire begins to melt after about 13 milliseconds, releasing the flare and insuring ignition.

### Capabilities

The fusee dispenser can release the full load of 48 flares in 15 to 20 seconds. Fusee flares fitted with the special caps are inexpensive and easy to obtain. They burn with ample duration and intensity for most fuel loads. The batteries provide enough power for 15 loadings before recharging. With modifications, the dispenser ignition may be connected directly to the aircraft electrical system.

### Limitations

Because of the low temperatures encountered during flight, reliable ignition of the first flare in a stack is sometimes difficult to achieve. Design modifications are currently being tested.



*Fusee dispenser.*

### Specifications

Capacity 48 flares  
Discharge rate to 3 flares per second  
Power requirements 24 V (dc) electrical system

### Availability

Drawings are available from:

Olin Corp.  
Box 727  
Morgan Hill, Calif. 95037  
(408) 779-2196 -

Information may be obtained from:

USDI Bureau of Land Management  
Fire Management Branch  
4700 East 72nd St.  
Anchorage, Alaska 99507  
(907) 344-5814

Boise Interagency Fire Center  
3905 Victor  
Boise, Idaho 83705  
(208) 384-9830  
FTS 554-9830

# Flying Drip Torch

## Function

The flying drip torch is an enormous drip torch suspended from a helicopter for aerial ignition. One torch uses a fuel gel that is not extinguished during the fall to the ground. The fuel is ignited with a glow plug controlled by the pilot.

## Description

Flying drip torches have been manufactured from oil drums and pipe. A solenoid valve controls the fuel flow and the fuel is ignited with a glow plug. The fuel gel model has an electrical fuel pump. The flying drip torch is suspended from the helicopter by cables to allow the pilot to jettison the unit if necessary.

## Techniques

The flying drip torch applies a gasoline-diesel mix or a special fuel gel. The fuel gel prevents the flames from being extinguished before they reach the ground. The fuel flow can be controlled with the solenoid valve to achieve optimum ignition. The glow plug may be turned off to reduce the safety hazard and prevent accidental ignition of areas not intended to burn.

## Capabilities

The flying drip torch is a simple and effective aerial ignition system for broadcast burning. Large areas can be ignited in a relatively short time. Fuel gel allows higher altitude operation and increases the margin of safety.

## Limitations

Since the flying drip torch is a low-intensity ignition system, fuel loads and weather conditions must be sufficient to carry the fire. Extreme caution is necessary for low altitude operation.

## Specifications

Tank capacity 20 to 80 gal (76 to 303 l)



*Flying drip torch.*

## Availability

### Flying drip torch:

Simplex Manufacturing Co.  
5224 Northeast 42nd Ave.  
Portland, Oreg. 97218  
(503) 281-0039

### Fuel gel:

Witco Chemicals  
Box 1470  
10100 Santa Monica Blvd.  
Los Angeles, Calif. 90067  
(213) 277-4511

### Information may be obtained from:

Environment Canada  
Canadian Forestry Service  
Pacific Forest Research Centre  
506 West Burnside  
Victoria, B.C., Canada V8B 1M5  
(604) 388-3811

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

# Electrical Discharge System

## Function

The electrical discharge system (EDS) was developed for quick, effective cultivation of field crops. Heavy-duty units have been adapted for brush control on rights-of-way; floodplains, rangelands, and other noncrop areas.

## Description

The EDS equipment produces a powerful electric charge and delivers it to the plants. Selectivity is based primarily on plant location and geometry.

Several safety devices are incorporated into the EDS equipment, such as sensors for the integrity of the ground connections; however, proper operator training and education is important for safe operation.

Systems are available mounted on railroad maintenance trucks, rubber-tired tractors, or articulated, all-wheel drive logging skidders.

## Specifications

Swath width 16 to 24 ft (4.9 to 7.3 m). Effective swath width varies with the density of vegetation.  
Electrical output 20 to 200 kW  
Power requirements (drawbar) 40 hp (30 kW) minimum

## Availability

Lasco, Inc.  
Box 187  
Vicksburg, Miss. 39180  
(601) 638-8001

## Techniques

Plants are killed on contact when the electrolytic solution in their vascular system is forced to conduct electricity. This rapidly increases the temperature and vapor pressure, ruptures the cells, and damages vital tissues.

## Capabilities

The EDS has effectively controlled vegetation up to 15 ft (4.6 m) tall. It can selectively control tall brush or weeds growing over a herbaceous, grass, or crop under-story. The EDS can be applied with few adverse environmental impacts.

## Limitations

Resprouting of controlled shrubs may occur. The EDS should be operated very carefully with proper training and supervision to insure the safety of the operators and bystanders.



*Electrical discharge system for brush control.*

## Flame Throwers

### Function

Flame throwers, flame sprayers, or flame torches ignite fires with an intense concentrated flame when fuel loads are too light or sparse for broadcast burning. They are also good for spot burning.

### Description

Flame throwers have flame nozzles attached to pressurized tanks with flexible hose. The fuel tanks are pressurized with hand pumps. Flame throwers are equipped with pressure gages and control valves. Most flame throwers burn kerosene, diesel fuel, or fuel oil, but a few operate on liquid propane gas.

### Techniques

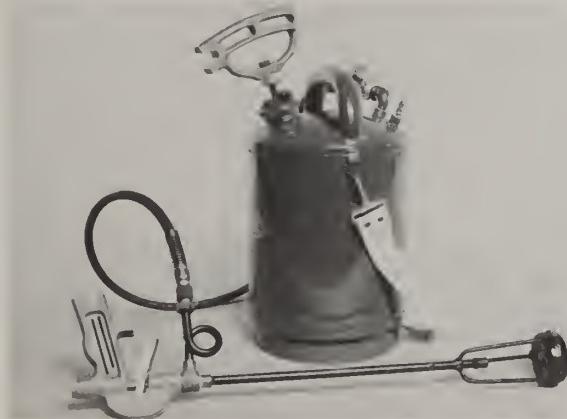
A high intensity, 2000° F (1093° C) flame is directed at the point of ignition and rapidly establishes an intense fire that will move forward as a solid wall of flame, burning the area completely. Flame throwers also ignite spot treatments.

### Capabilities

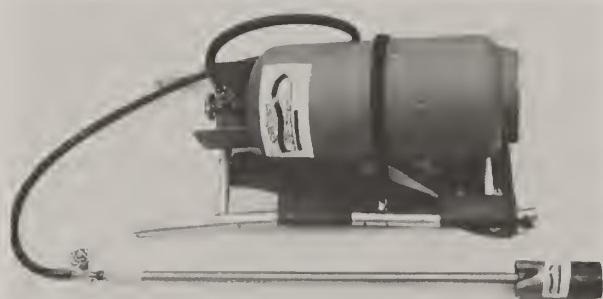
Flame throwers are adapted to light or sparse fuel loads on areas where drip burners prove inadequate. Flame throwers can burn more isolated open growing brush effectively under conditions that allow easier control.

### Limitations

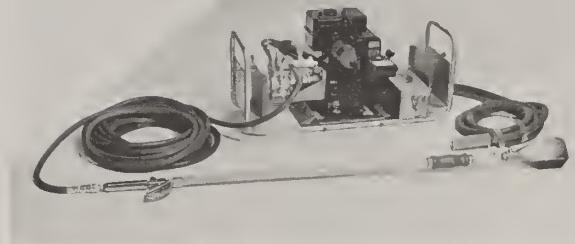
Flame throwers produce very intense flames that carry up to 12 ft (3.7 m), necessitating careful operation. Although portable, flame throwers allow less mobility than drip torches.



Pneumatic flame thrower.



Propane flame gun with a backpack tank.



Large, vehicle-mounted flame thrower.



Igniting a burn using a backpack flame gun.

## Specifications

Tank capacity 1.5 to 5 gal (5.7 to 18.9 l)  
Operating pressure 40 to 200 lb/in<sup>2</sup> (276 to 1379 kPa)  
Flame reach to 12 ft (3.7 m)  
Temperature 2000° F (1093° C)

## Availability

### Petroleum fuel:

Aeroil Products, Inc.  
10 Wesley St. South  
Hackensack, N.J. 07606  
(201) 343-5200

Bartlett Manufacturing Co.  
3003 East Grand Blvd.  
Detroit, Mich. 48202  
(313) 873-7300

Ben Meadows Co.  
3589 Broad St.  
Atlanta, Ga. 30366  
(404) 455-0907

R. E. Chapin Manufacturing Works, Inc.  
29 Liberty St.  
Batavia, N.Y. 14020  
(716) 343-3140

Forestec Ltd.  
6393 Bayne St.  
Halifax, Nova Scotia, Canada, B3K 2V6  
(902) 455-4062

Forestry Suppliers, Inc.  
Box 8397  
Jackson, Miss. 39204  
(601) 354-3565

H. D. Hudson Manufacturing Co.  
500 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 644-2830

Panama Pump Co.  
Box 689  
Hattiesburg, Miss. 39402  
(601) 544-4251

Root Lowell Corp., Div.  
1000 Foreman Rd.  
Lowell, Mich. 49331  
(616) 897-9212

Western Fire Equipment Co.  
440 Valley Dr.  
Brisbane, Calif. 94005  
(415) 467-5650

### Propane Gas:

Burners, Inc.  
19011 West Davison St.  
Detroit, Mich. 48223  
(313) 838-6212

Flame Engineering, Inc.  
Box 577  
LaCross, Kans. 67548  
(913) 222-2837

Goss, Inc.  
1511 Route 8  
Glenshaw, Pa. 15116  
(412) 961-0340

Hauck Manufacturing Co.  
Box 90  
Lebanon, Pa. 17042  
(717) 272-3051

## Drip Torch

### Function

Drip torches ignite controlled burns or backfires and are widely used on forest and rangeland burning projects and wildfires. They have also applied herbicide to individual trees or small stands of brush.



### Description

Drip torches consist of a tank to hold the fuel, a valve to control the fuel flow, a long wand to direct the flame, and a fuel ignitor on the tip of the wand. Hand-held, backpack, and drag-type drip torches are available.

### Techniques

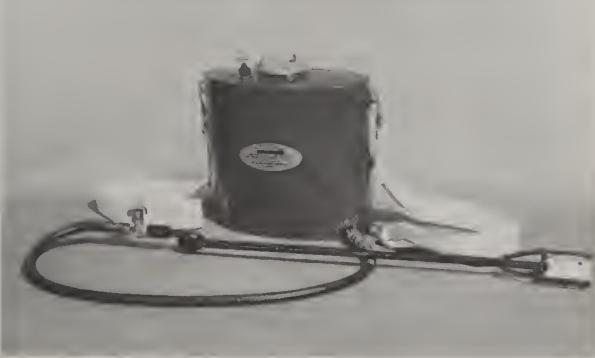
The petroleum fuel drips out the end of the wand. The fuel is ignited by the burning ignitor and the flaming fuel is dripped on the ground to start the fire. The fuel ignitor can be replaced with a sponge for effective herbicide applications to individual plants or small stands.

### Capabilities

Drip torches are useful where mobility is required for successful controlled burns or in wildfire situations. The operator can quickly ignite a wide strip of land.

### Limitations

Fuel loadings must be sufficient to effectively carry a low-intensity broadcast burn. For large burns several persons with drip torches may be deployed along a wide strip.



*Backpack drip torch.*

*Conventional drip torch.*



*Ignition with a conventional drip torch.*



*Drag torch.*

#### Specifications

##### Handheld:

Tank capacity 1.5 to 6 qt (1.4 to 5.7 l)  
Wand length 12 to 33 in (30 to 83 cm)

#### Availability

Ben Meadows Co.  
3589 Broad St.  
Atlanta, Ga. 30366  
(404) 455-0907

Forestec, Ltd.  
6393 Bayne St.  
Halifax, Nova Scotia, Canada B3K 2V6  
(902) 455-4062

Forestry Suppliers, Inc.  
Box 8397  
Jackson, Miss. 39204  
(601) 354-3565

Panama Pump Co.  
Box 689  
Hattiesburg, Miss. 39402  
(601) 544-4251

Western Fire Equipment Co.  
440 Valley Dr.  
Brisbane, Calif. 94005  
(414) 467-5650



*Typical moldboard plow.*

The equipment described in this section is for initial ground preparation. This equipment aids plant establishment by conditioning the soil, preventing erosion, or retaining moisture. Final seedbed preparation equipment is included under the section bearing that title and fertilizer broadcasters are included under *Seeding*.

Because of the high cost of seeding, from \$12 to \$100 per acre (\$30 to \$250/ha), natural revegetation through improved management should be considered when planning to improve range. Generally, seeding should be considered only on lands with less than 15 percent desirable perennial species.

Seeding for forage production should be restricted to the best available sites in terms of available moisture

and plant nutrients. Reclamation of disturbed land is enhanced by ground preparation techniques that reduce erosion and improve water availability.

Ground preparation should be aimed at reducing competition while providing sufficient moisture and plant nutrients. The most effective seedbed preparation technique for rangeland is usually clean tillage and fallow. The erosion hazard may be reduced by leaving the soil rough plowed until just before seeding. Preparatory crops may be planted on reclamation sites or in areas with sufficient moisture and nutrients. Other common seedbed preparation techniques include chemical applications and burning. These techniques and applicative equipment are discussed under *Controlling Plants with Chemicals* and *Controlling Plants with Heat*, respectively.

## Moldboard Plows

### Function

Moldboard plows are primary tillage implements to turn over heavy soils or sod. They are designed for agricultural operations.

### Description

Moldboard plows have large curved bottoms, or moldboards, attached to a heavy-duty frame. The moldboards have blades, or shares, along the bottom edge and large curved wings above. They are raised and lowered hydraulically and are adjustable for depth. Some plows feature spring-loaded or hydraulic reset mechanisms that enable each bottom to rise independently when an obstruction is encountered and immediately return to its operating depth. Moldboard plows may attach directly to the three-point hitch of a tractor or they may be towed. Most attached models have furrow wheels for support and depth control.

### Capabilities

Moldboard plows can effectively plow sod, trash, undesirable annuals, or perennial forbs. They leave a rough surface that helps reduce erosion on fallow lands.

### Limitations

Moldboard plows are primarily farm implements. They are ineffective on hard, sticky, or rocky soil. Moldboard plows have high power requirements and must be operated at slow speeds.

### Specifications

|   |
|---|
| Width 1 to 18 ft (.3 to 5.5 m)                              |
| Depth 5 to 24 in (13 to 61 cm)                              |
| Number of bottoms 1 to 12                                   |
| Power requirements (drawbar) 20 to 245 hp<br>(15 to 183 kW) |

### Availability

Moldboard plows are available from most farm implement manufacturers and farm equipment dealers.

### Techniques

The moldboard plow is pulled through the ground at the desired depth. The shares slice under the soil layer and the curved wings turn the slices up and over.

## Offset Disks

### Function

Offset disks are designed to chop and turn surface trash under. Large offset disks can effectively control light to moderate stands of sprouting brush.

### Description

Offset disks consist of two rows, or gangs, of disks set at an angle to each other. Each gang has a separate frame and axle assembly. The angle is adjustable for varying soil conditions. The disks may have notched or straight edges. Most offset disks have wheels that are raised or lowered hydraulically for transport and to regulate operating depth.

### Techniques

Offset disks are towed over the area to be treated. The front gang of disks turns the soil one way and the rear gang turns it the other, giving a double disking action. Trash or brush is chopped up and incorporated into the soil. Two passes are recommended for brush control. Soil amendments, such as fertilizer or herbicide, can be disked into the surface layers of the soil where they are more readily available to plants.

### Capabilities

Offset disks can effectively control brush while preparing an adequate seedbed and often break up surface soil compaction on reclamation areas or construction sites. They are well suited to dry, heavy soil and can be used on moderately rocky soil.

### Limitations

Offset disks cannot be operated in soils with many large rocks. When a large rock is encountered, the entire weight of the gang rests on one or two disks, which can break disks. Offset disks should not be used on slopes over 30 percent. Subsurface compaction cannot be treated with offset disks.

### Specifications

Cutting width 6 to 32 ft (1.8 to 9.8 m)  
Depth 8 to 16 in (20 to 91 cm)  
Disk diameter 28 to 50 in (71 to 127 cm)  
Weight 500 lb per ft (744 kg/m) recommended  
Power requirements (drawbar) 60 to 315 hp  
(45 to 235 kW)



*Large offset disk.*



*Disking action of the offset disk gangs.*

### Availability

AMCO Products  
1 AMCO Dr.  
Yazoo City, Miss. 39194  
(601) 764-4464

Austin Products, Inc.  
Athens Plow Div.  
Box 609  
Athens, Tenn. 37303  
(615) 745-3561

J. I. Case Co.  
700 State St.  
 Racine, Wis. 53404  
(414) 636-6011

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

International Harvester Co.  
Agricultural Equip. Div.  
401 North Michigan  
Chicago, Ill. 60611  
(312) 836-3874

Kewanee Machinery Div.  
Chromalloy America Corp.  
1516 Burlington Ave.  
Kewanee, Ill. 61443  
(309) 852-2191

Miller Manufacturing Co.  
Box 305  
Straton, Nebr. 69043  
(308) 276-2131

Napier Grasslands Pty., Ltd.  
Box 244  
Taree, NSW, 2430  
Australia

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4450

Towner Manufacturing Co.  
Box 6096  
Santa Ana, Calif. 92706  
(714) 542-6767

# One-Way Disk Plows

## Function

One-way disk plows are designed for deep plowing in one direction. They are similar to moldboard plows in effectiveness.

## Description

One-way disk plows have a single row of large disks that can penetrate deeply into the soil.

They may be mounted on a common axle or on individual supports. The frame may be mounted on the tractor or supported by wheels. The plowing depth can be adjusted hydraulically. Some models have adjustable pitches and angles to accommodate a wide variety of conditions.

## Techniques

One-way disk plows are pulled through the soil by tractors. The single gang penetrates the soil and turns it in one direction. Disks on a common axle rotate as a unit. Individually mounted disks can rotate independently.

## Capabilities

One-way disks are useful for deep plowing, loosening, mixing, or aerating the soil. They can effectively control deep-rooted plants on plowable ground. They can plow soil that is too hard or sticky for moldboard plows.

## Limitations

One-way disk plows are restricted to fairly rock-free ground. Disks may break on large rocks because the entire weight of the implement is transferred to a few disks. One-way disk plows have heavy drafts that require slow speeds and large amounts of power.

## Specifications

Cutting width 3 ft 9 in to 20 ft (1.1 to 6.2 m)  
Depth to 30 in (76 cm)  
Power requirements (drawbar) 20 to 215 hp  
(23 to 160 kW)



*One-way tiller disk plow.*



*Large one-way disk plow with separate disks.*

## Availability

|   |  |
|---|--|
| Austin Products, Inc.<br>Athens Plow Div.<br>Box 609<br>Athens, Tenn. 37303<br>(615) 745-3561 | Napier Grasslands Pty., Ltd.<br>Box 244<br>Taree, NSW, 2430<br>Australia |
|---|--|

|   |   |
|---|---|
| Deere and Co.<br>John Deere Rd.<br>Moline, Ill. 61265<br>(309) 752-8000 | Towner Manufacturing Co.<br>Box 6096<br>Santa Ana, Calif. 92706<br>(714) 542-6767 |
|---|---|

# Brushland Plow

## Function

The brushland plow was designed specifically for range-land by the USDA Forest Service Equipment Development Center at San Dimas, California. It has been very useful for controlling moderate brush in rough, rocky, or uneven terrain.

## Description

The brushland plow consists of seven pairs of disks mounted on spring-loaded arms. The arms are attached to a heavy-duty frame supported by three wheels. Each pair of disks consists of a 24-in (61 cm) disk and a 28-in (71 cm) disk, set at a 4-degree incline so they plow at the same depth. The brushland plow is designed to plow at a depth of 4 in (10 cm). When an obstruction is encountered, the spring-loaded arms allow each pair of disks to ride over it independently. The draft angle of the plow is adjustable from 30 to 40 degrees.

## Techniques

Brushland plows are towed, singly or in tandem, through the area to be treated. The spring-loaded arms allow each pair of disks to independently seek the optimum operating depth. One pass is usually sufficient, but two passes may be required in heavy brush or on very rough ground.

## Capabilities

The brushland plows effectively control moderate to heavy stands of low, non-sprouting brush, while rough-plowing the land. Over 90 percent kills are usually obtained for sagebrush (*Artemesia spp.*). Low breakage and little required maintenance are outstanding features. The brushland plow is well suited to rocky, rough, and uneven terrain.

## Limitations

The brushland plow does not operate deep enough to control most sprouting shrubs. The plows are also expensive and somewhat difficult to transport. Use of the brushland plow has diminished in recent years.



Brushland plow.

## Specifications

### Standard:

Cutting width 9 ft 7 in (3.1 m)  
Depth 4 in (10 cm)

### Power requirements (drawbar):

40 hp (30 kW) single on level ground  
60 to 70 hp (45 to 52 kW) single on steep slopes  
80 hp (60 kW) tandem on level ground  
100 to 124 hp (75 to 93 kW) dual on steep slopes

## Availability

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

Drawings (RM2-01 to 22) and Service and Parts Manual are available from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

# Plow Seeder

## Function

The plow-seeder system was developed by the British Columbia Ministry of Agriculture, Agricultural Engineering Branch under contract from the Development, Research, and Evaluation of Agricultural Machinery Program (DREAM). The system accomplishes once-over brush control and seeding of depleted rangeland with steep uneven terrain, rocky soils, and dense growth.

## Description

The plow-seeder system consists of a flexible, heavy-duty, off-set disk plow with a free-floating packer-seeder pulled in tandem. Each 12-ft (3.6 m) gang of the offset disk is made up of four individually suspended subgangs. Each subgang is loaded and controlled by a hydraulic cylinder. This design allows variable loading of 0 to 833 lb (0 to 378 kg) per disk with control from the tractor seat. The subgangs can independently absorb impacts from obstacles. The packer-seeder consists of a seed-box spreader mounted between two sets of rollers. Both front and rear roller assemblies are made up of four packer sections. The two rear, outside sections are mounted solidly in the frame for stability, while the remaining sections are independently suspended.

## Techniques

The plow-seeder system is pulled over the area to be treated. The flexible offset disk provides brush control and primary tillage. The packer-seeder firms the seed-bed, broadcasts seed, and covers the seed. Double disking may be necessary in dense sod.

## Capabilities

The plow-seeder system combines the features of the brushland plow, offset disk, flexible cultipacker, and seed-box spreader. It enables once-over conversion of sagebrush to grassland. It was designed for operation on steep slopes, rough terrain, and rocky ground.

## Limitations

The system is not commercially available and must be custom-made. The plow-seeder does not penetrate deep enough for adequate control of most sprouting shrubs. The system may be difficult to transport.

### Specifications

Width 12 ft (3.1 m)

Plowing depth 3 to 4 in (8 to 10 cm)

Power requirements (flywheel):

93 to 140 hp (69 to 104 kW) on level ground

128 to 180 hp (95 to 135 kW) on steep slopes



*Plow section of plow-seeder system featuring hydraulic control of each disk subgang.*



*Seeder section of plow-seeder system with independently suspended soil packer sections.*

### Availability

Information may be obtained from:

Agriculture Canada  
Range Research Station  
3015 Ord Rd.  
Kamloops, B.C., Canada V2B 8A9  
(604) 376-5565

British Columbia Ministry of Agriculture  
166 Oriole Rd.  
Kamloops, B.C., Canada V2C 4N7  
(604) 374-3614

## Pitting Disk Plows

### Function

Pitting disk plows create long, narrow pits or catch basins that accumulate rain or snow, and hold runoff. The increased availability of water in and around the pits stimulates plant growth and helps establish seedlings.

### Description

Pitting disk plows are mainly modified one-way disk or brushland plows. The standard disks are simply replaced with cut-out disks. One custom-made pitting disk plow has a cut-out disk on each end of two axles placed in a shallow V-shaped configuration. Broadcast seeders may be mounted on pitting disk plows.

### Techniques

The cut-out disks only contact the ground during part of each revolution, leaving alternate strips of plowed ground and undisturbed soil. Seed is often broadcast around the furrows. Pitting the higher areas of the watershed traps runoff on the slopes for increased forage production and reduced erosion.

### Capabilities

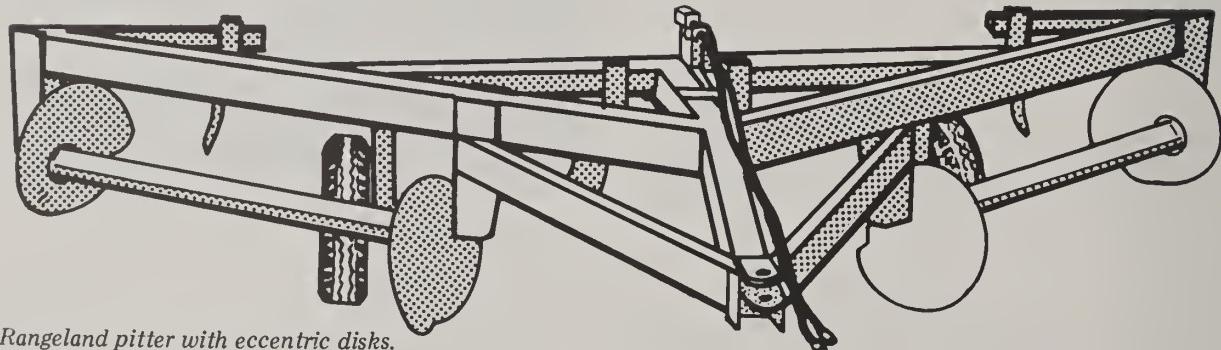
Pitting disk plows scuffle the ground surface so that snow or runoff may be trapped. The moisture that is retained contributes to increased plant growth and seedling survival and reduces erosion.

### Limitations

Pitting disk plows are not effective in dense sod. Furrows formed in sandy soil may fill in rapidly. Broadcast seeding does not allow precise seed placement. Seed that falls into the furrows may be covered too deeply to survive.



*Cutout disks on a pitting disk plow.*



*Rangeland pitter with eccentric disks.*

### Specifications

Width 3 ft 9 in to 15 ft (1.1 to 4.6 m)  
Depth 4 in (10 cm)  
Power requirements (drawbar) 30 to 215 hp (23 to 160 kW)

### Availability

G. N. Scranton  
Box 229  
Lamar, Colo. 81052  
(303) 336-5317

Cut-out disks may be fabricated at most machine shops.

# Chisel Plows

## Function

Chisel plows are tractor-drawn, primary tillage implements. They break up compacted surface soil and increase water infiltration. They can be used to incorporate soil amendments. Chisel plows are often used in rocky areas.

## Description

Chisel plows have curved shanks mounted along frame members or toolbars with spring-loaded clamps. A wide variety of chisel teeth, sweeps, and shovels may be attached to the tips of the shanks for various tillage needs. The spring clamps enable each shank to clear obstacles independently. Chisel plow frames have from two to six cross members. They may be mounted on tractors or pulled behind them. Large frames have folding wings for easy transport. Plowing depth is controlled hydraulically.

## Techniques

Chisel plows are simply pulled through the soil. The action of the shanks scarifies the ground and opens it up. The narrow furrows trap moisture and reduce wind erosion. Chisel points, shovels, and sweeps destroy plant roots and loosen the soil from underneath.

## Capabilities

Chisel plows are suited to rocky land because the narrow, flexible shanks and independent spring action allow the tips to bypass surface or subsurface rocks. Durable, reversible chisel tips should be provided for operation in rocky areas. Chisel plows prepare excellent seedbeds for broadcast seeding. They can effectively mix amendments with the soil.

## Limitations

Rocky soils cause excessive wear on the plow tips. Rocks that are moved to the surface by the action of chisel plows may interfere with secondary tillage implements or drills. The furrows tend to wear down quickly during severe weather. Low ground clearance and trash buildup prevent effective brush control with chisel plows.



*Chisel plow.*

### Specifications

Width 5 to 57 ft (1.5 to 17.4 m)  
Depth 4 to 12 in (10 to 30 cm)  
Shank spacing 12 to 32 in (30 to 81 cm)  
Power requirements (drawbar) 30 to 315 hp  
(22 to 235 kW)

### Availability

Chisel plows are available from most farm implement manufacturers or farm equipment dealers.

## Subsoilers

### Function

Subsoilers penetrate deep into the soil to fracture compacted layers for better drainage and root development. Subsoilers effectively lift the deep soil and mix it with the surface soil. They can incorporate amendments into the soil.

### Description

Subsoilers are large, stout shanks attached solidly to a toolbar or frame with shear bolts. Shanks are curved and have replaceable tips. The subsoilers are raised and lowered hydraulically. Some models feature power-take-off (PTO)-driven vibrating devices.

### Techniques

Subsoilers are pulled through the soil at the desired depth. Best results are obtained when the soil is dry. Subsoiling should be performed on the contour to minimize the erosion hazard.

### Capabilities

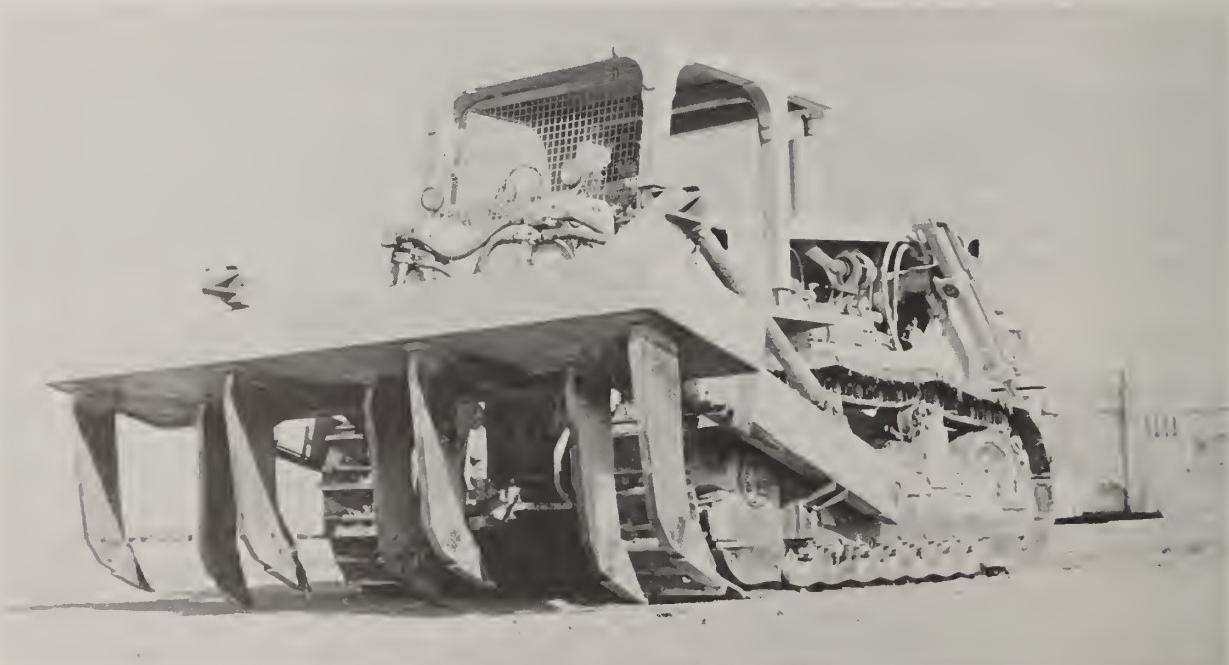
Subsoilers fracture hardpan and stimulate increased growth. Subsoiling makes more moisture and nutrients available to plant roots.

### Limitations

Subsoilers are effective only when furrows last and where hardpan restricts plant growth. They also have high power requirements.



*V-plow subsoiler.*



*Large subsoilers on a crawler tractor.*



*Vibrating subsoiler.*

### Specifications

Width 7 ft 6 in to 18 ft (2.3 to 5.5 m)  
Depth to 30 in (76 cm)  
Shank spacing 18 to 40 in (36 to 102 cm)  
Power requirements (drawbar) 55 to 315 hp  
(41 to 235 kW)

### Availability

Agristruction, Inc.  
41286 Rd. 124  
Orosi, Calif. 93647  
(209) 528-4788

Allis Chalmers  
Agricultural Equipment Div.  
Box 512  
Milwaukee, Wis. 53201  
(414) 475-2000

Brillion Iron Works  
200 Park Ave.  
Brillion, Wis. 54110  
(414) 756-2121

Bush Hog  
Division of Allied Products Corp.  
Box 1039  
Selma, Ala. 36701  
(205) 872-6261

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6011

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Dickey Machine Works  
Box 5610  
Pine Bluff, Ark. 71601  
(501) 536-1300

Forrest City Machine Works  
Box 984  
Forrest City, Ark. 72335  
(501) 633-1514

Hiniker Co.  
Box 3407  
Mankato, Minn. 56001  
(507) 625-6621

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(302) 836-3874

Landoll Corp.  
1700 May St.  
Marysville, Kans. 66508  
(913) 562-5381

Lubbock Manufacturing Co.  
Box 1589  
Lubbock, Tex. 79408  
(806) 762-5261

Napier Grasslands Property, Ltd.  
Box 244  
Taree, NSW, 2430  
Australia

Plant Plows, Inc.  
Box 3779  
Amarillo, Tex. 79106  
(806) 355-9786

United Farm Tools, Inc.  
Box 9175  
South Charleston, W. Va. 25309  
(304) 768-8221

# Rippers

## Function

Rippers shatter and fracture rock and compacted soil. They penetrate deeply to improve drainage. Rippers are basic construction implements, to prepare material for loading and hauling.

## Description

Rippers attach to tractors, loaders, or motor graders. They are large shanks attached to a tool bar or a special hitch. The tool bar is supported by large carrying beams and is manipulated by hydraulic cylinders. Interchangeable shank tips and guards protect the shank from abrasion and breakage.

## Techniques

Rippers are moved through the ground, creating very deep, narrow furrows. They can break rock and hard soil into sizes suitable for loading and hauling.

## Capabilities

Rippers can break up compacted soils and surface crusts, thereby improving water infiltration and root penetration into the soil. Ripping compacted soil before planting enhances plant survival.

## Limitations

Ripping is not well suited to steep slopes or soils over bedrock. If the furrows fill in quickly, sustained increases in forage production will not be realized. Rippers do not form adequate seedbeds. They leave the material in large chunks and pull up large rocks. The soil should be reworked with a chisel plow or disk plow to break up the large pieces.



Standard ripper.



Large ripper for deep penetration.

## Specifications

Depth to 7 ft (2.1 m)  
Power requirements (flywheel) 172 hp (128 kW)  
minimum

## Availability

Agristruction, Inc.  
41286 Road 124  
Orosi, Calif. 93647  
(209) 528-4788

American Tractor Equip. Co.  
9131 San Leandro St.  
Oakland, Calif. 94603  
(415) 638-2466

CRC-Kelley Products  
Box 4700  
Brownsville, Tex. 78520  
(512) 546-5346

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6011

Caterpillar Tractor Co.  
100 Northeast Adams  
Peoria, Ill. 61629  
(309) 675-1000

Clark Equipment Co.  
Michigan Div.  
Box 547  
Benton Harbor, Mich. 49022  
(616) 927-7200

Fiat-Allis Const. Mach., Inc.  
106 Wilmont Rd.  
Deerfield, Ill. 62710  
(312) 948-5500

H&L Tooth Co.  
1540 S. Greenwood Ave.  
Montebello, Calif. 90640  
(213) 721-5146

# Contour (Holt) Trenchers

## Function

Contour (Holt) trenchers are designed for trenching slopes to reduce runoff and conserve moisture. The trenches prevent erosion and promote more vigorous plant growth. Flood control, soil conservation, and watershed rehabilitation are aided by trenching the upper slopes of an eroded drainage.

## Description

Contour (Holt) trenchers are basically two-bottom, reversible disk plows. Two disks, either 28 or 32 in (71 or 81 cm) in diameter, are mounted individually on a cross bar. The cross bar pivots under a main support bar attached to the tractor hitch. The trencher disks swivel to allow operation while going both directions on the slope. The position of the cross bar and disks is controlled with hydraulic cylinders. Some models are equipped with a furrow wheel.

## Techniques

Contour (Holt) trenchers are pulled along the contour of a slope with crawler tractors. They excavate trenches to 12 in (30 cm) deep and up to 24 in (61 cm) wide. The trenches intercept runoff before erosive speeds are reached. Water is absorbed by the soil near the trenches and made available to plants. Eroded slopes should be broadcast seeded to quickly establish vegetative cover.

## Capabilities

Contour (Holt) trenchers can operate on slopes up to 45 percent. They can create trenches in a variety of configurations depending on the position of the disks. Improved hitches allow easy maneuvering. Contour (Holt) trenchers have been used for forest site preparation. Tree seedlings are placed in the trenches to take advantage of the available water.

## Limitations

Safety precludes contour trenching on slopes greater than 45 percent. Contours should be followed very closely to prevent runoff along the trenches and damage to the watershed.

Contour trenches are less effective on rocky slopes.



*Double-disk contour trencher.*

## Specifications

|  |
|--|
| Disk size 28 to 32 in (71 to 81 cm)                        |
| Weight 1,450 lb (658 kg)                                   |
| Depth to 10 in (25 cm)                                     |
| Power requirements (flywheel) 42 to 60 hp<br>(31 to 45 kW) |

## Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

## Rocky Mountain Trencher

### Function

The Rocky Mountain trencher builds trenches in slopes for watershed and range improvement. The trenches intercept runoff and provide moisture for increased plant growth and can effectively rehabilitate depleted watersheds by reducing runoff and rejuvenating vegetation.

### Description

The Rocky Mountain trencher consists of a single, large disk on a stout shank. The disk is 28 in (71 cm) in diameter. The shank is spring-loaded to absorb shocks. It is mounted on a horizontal supporting bar with a hinge that allows the operator to reverse the plow on a return pass. The supporting bar is attached to the tractor hitch. Springs on each side of the supporting bar absorb lateral shocks.

### Techniques

The Rocky Mountain trencher is pulled over the slope on the contour. The tractor hitch enables the trencher to be raised hydraulically to increase maneuverability. Moisture is intercepted by the trenches and made available for plant growth or seedling establishment.

### Capabilities

The Rocky Mountain trencher builds trenches up to 18 in (46 cm) deep and 24 in (61 cm) wide on slopes up to 45 percent. The spring-loaded system allows operation on rough, moderately rocky slopes.

### Limitations

Contours should be followed carefully to avoid erosion. The trencher should not be operated on slopes over 45 percent because of safety considerations.

#### Specifications

Disk size 28 in (71 cm)  
Weight 900 lb (408 kg)  
Depth to 12 in (30 cm)  
Power requirements (flywheel) 42 to 60 hp  
(31 to 45 kW)

#### Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000



*Rocky Mountain single-disk trencher.*

# Fireplows

## Function

Fireplows were designed to build wide, shallow firelines. They have been adapted for building contour trenches and for removing heavy growth when interseeding.

## Description

Fireplows have a single disk coulter centered in front of a V-shaped lister share. One or two large disks are located in back of the lister share on each side of the plow. Many fireplows have moldboard wings attached to each side of the frame in back of the disks. Fireplows may be mounted on crawler tractors or towed. They are controlled hydraulically. Some plows have spring-loaded reset mechanisms allowing them to ride over obstructions and return to their original working position.

## Techniques

Fireplows cut wide, flat-bottomed trenches up to 6 in (15 cm) deep. The coulter disks chop debris, the lister shares break the soil, and the disks complete the cut and move the soil to the sides. The soil removed from the trench is turned over along the sides, adding to the effective width of the firebreak.

## Capabilities

Fireplows are useful trenching machines. They can build firelines quickly and efficiently. They are well adapted to interseeding brushy lands because they create wide, flat-bottomed trenches. They are also used for contour trenching.

## Limitations

Contours of the slopes should be carefully followed when trenching to avoid creating an erosion hazard. Fireplow trenches may not retain water on slopes as well as other implements because the soil is cast both uphill and downhill. Fireplows may not operate deep enough to control sprouting plants when used for interseeding.

### Specifications

Width 30 to 72 in (76 to 183 cm)  
Depth 2 to 6 in (5.1 to 15.2 cm)  
Coulter disk diameter 20 to 30 in (51 to 76 cm)  
Power requirements (flywheel) 37 to 172 hp (28 to 128 kW)



*Three-point mounted fire plow.*



*Fireplow cutting a wide, shallow furrow.*



*Towed fireplow.*

### Availability

Hester Fireline Plow Co., Inc.  
Box 646  
Lake City, Fla. 32055  
(904) 755-0960

Mathis Plow Co.  
Box 1567  
Lake City, Fla. 32055  
(904) 752-4067

Southern Iron & Equip. Co.  
5522 New Peachtree Rd.  
Chamblee, Ga. 30341  
(404) 452-3176

## **Basin Blade**

### **Function**

The basin blade scoops out large basins or depressions along slopes. Moisture accumulates in these basins to provide a favorable microsite for plant growth. The large basins also reduce wind erosion.

### **Description**

The basin blade is a large, crescent-shaped, heavy steel blade mounted on the rear of a crawler tractor. The blade is mounted on a parallelogram multiple-ripper shank and is raised, lowered, and tilted hydraulically. Several replaceable scarifying teeth are located along the bottom edge of the blade.

### **Techniques**

The basin blade is most often used in strip mine reclamation. The tractor is driven along the contour of a slope and the blade is periodically raised and lowered to form large depressions. Seed is then broadcast along the slope. The basins provide a favorable microsite for seed germination and growth by trapping moisture and protecting the seedlings from wind.

### **Capabilities**

The large basins provide the advantages of terracing with fewer hazards and less expense. They collect runoff and trap snow and blowing topsoil. The furrows formed by the scarifying teeth help retain broadcast seed and fertilizer and promote increased infiltration.

### **Limitations**

The basin blade is well suited for revegetation on slopes, but other implements are better suited for level ground. Seed broadcast on the upwind side of the depressions may be covered too deeply for adequate growth. The increased moisture provided by the basins may be stored too far underground to be available to many plants.



*Basin blade on a large crawler tractor.*

### **Specifications**

Width 10 ft (3 m)

Depth to 36 in (91 cm)

Power requirements (flywheel) 290 to 370 hp  
(216 to 276 kW)

### **Availability**

Drawings (No. 619) are available from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 549-3157  
FTS 585-3163

# Contour Furrower

## Function

The contour furrower breaks up compacted soil, forms furrows, dams the furrows at intervals, and broadcasts seed. It is useful for reclaiming deteriorated rangelands, preventing soil erosion, and improving moisture conditions.

## Description

The contour furrower has four major components: two subsoilers with replaceable tips, two pairs of offset 26-in (66 cm) disks, two four-blade paddlewheel dammers, and a seed box spreader. These components are attached to a wheeled frame 8 ft (2.4 m) wide and 18 ft (5.5 m) long. The entire apparatus is raised or lowered by a hydraulic cylinder that also acts as a shock absorber for the hitch. A cable lift mechanism is also available. The dammers and the seeder spreader are operated by a single, trailing wheel. The depth of penetration, width of the furrows, and distance between check dams may be adjusted by altering the subsoiler height, disk angles, and paddlewheel trip mechanism, respectively.

## Techniques

With each pass the contour furrower builds a pair of furrows 5 ft (1.5 m) apart. The subsoilers break up surface compaction and hardpan and the disk pairs cut furrows in the ripped soil. The offset configuration of the disks builds banks on both sides of the furrow. Check dams are formed by pushing soil in front of a paddlewheel blade locked in place until released by the trip mechanism. The paddlewheel then rotates, locking the next blade in place and leaving a soil dam behind. Seed is broadcast into the furrows from a seed box spreader mounted at the rear of the implement.

## Capabilities

The contour furrower is well suited for watershed rehabilitation on fairly level land and on slopes up to 20 percent. However, it is best adapted to slopes of less than 10 percent where it improves infiltration and percolation in heavy, compacted soils. The check dams provide catch basins for runoff and make the exact following of contours less critical.

## Limitations

The contour furrower should not operate in rocky soils because the disks may break. Uncovered broadcast seed is moved by wind or water. Use of the contour furrower has diminished in recent years.



*Contour furrower.*

## Specifications

Penetration depth to 12 in (30 cm)  
Furrow depth to 10 in (25 cm)  
Furrow width 9 to 24 in (23 to 61 cm)  
Check dam spacing 9 to 96 ft (2.7 to 29.3 m)  
Power requirements (drawbar):  
    55 hp (41 kW) light soils, medium depth  
    75 hp (56 kW) heavy soils, medium depth  
    120 hp (89 kW) heavy soils, full depth

## Availability

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

Drawings (RM25-01 to 14) and a Service and Parts Manual are available from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

# Gouger

## Function

The gouger creates numerous depressions in the soil surface. These depressions provide a suitable microclimate for plant establishment by increasing moisture availability, preventing wind and water erosion, and providing shade.

## Description

The gouger consists of three to five semicircular heavy steel blades attached to solid arms. Each blade has three scarifying teeth along the bottom edge. The arms are attached to a heavy-duty frame with spring-loading mechanisms. They may be mounted in either one- or two-row configurations. The frame is supported with side wheels that are periodically raised and lowered to allow the blades to scoop out depressions. The unit is operated hydraulically and features positive depth control and automatic up and down cycling. A seedbox spreader is mounted on the rear of the machine to broadcast seed into the depressions.



*Modified Hodder gouger.*

## Techniques

The gouger is towed behind a tractor. The hydraulically powered automatic cycling system moves the frame up and down in relation to the wheels to create depressions. The depth of the depressions, cycle rate, and blade configuration can be varied to suit the site conditions. Average production rates have varied from 2.4 to 2.8 acres (1 to 1.1 ha) per hour.

## Capabilities

The gouger is very useful for revegetation and rehabilitation of disturbed lands. The depressions provide moisture, shade, and shelter for seed germination and growth. The gouger creates more and larger depressions than similar equipment. The automatic cycling and hydraulic depth control make it easier to operate and the adjustable cycle rate and variable blade configurations contribute to its versatility. The spring-loaded blade arms enable it to operate in fairly rocky ground.

## Limitations

The gouger is designed for slopes of 20 percent or less. Broadcast seed may be removed or buried by wind or excess water.

## Specifications

Implement width 11 ft (3.4 m)  
Depression width 15 to 22 in (38 to 56 cm)  
Depression length 3 to 4 ft (.9 to 1.2 m)  
Depth 6 to 10 in (15 to 25 cm) recommended  
Power requirements (drawbar) 50 hp (37 kW)  
minimum

## Availability

Drawing (No. 583) is available from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 549-3157  
FTS 585-3157

## Land Imprinter

### Function

The land imprinter creates a series of precise geometric patterns on the ground surface to control erosion and to direct infiltration. This is accomplished without tillage so that the soil structure and profile is preserved and the mulch material from the crushed brush is retained near the surface. The imprinting treatment produces an excellent, rainwater-irrigated seedbed for establishing broadcast seed or rejuvenating native grass.

### Description

The land imprinter is essentially a towed rolling chopper with two interchangeable drums mounted on a common axle. Several different drums are available to obtain a variety of imprint patterns. The drums can be weighted by filling them with water. A rotary spreader and hanging drag chains are usually mounted on the rear of the imprinter frame for broadcast seeding. The land imprinter is capable of production rates of over 4 acres (1.6 ha) per hour.

### Techniques

The land imprinter is pulled over the area to be treated. The device crushes and chops brush, mixes and imbeds surface debris or seed, and forms stable, complex

impressions in the ground. The resulting closed, V-shaped furrows can collect up to 2 in (5 cm) of rainfall and disperse concentrated runoff. The slight firming action of the treatment helps prevent splash and sheet erosion. The rotary spreader distributes seed over both treated and untreated ground. In this manner, some of the seed is imbedded on the return pass, while the rest is collected in grooves of the imprinted pattern where the rainfall and runoff is directed. The moist, mulch-lined furrows also provide a suitable micro-habitat for soil organisms.

### Capabilities

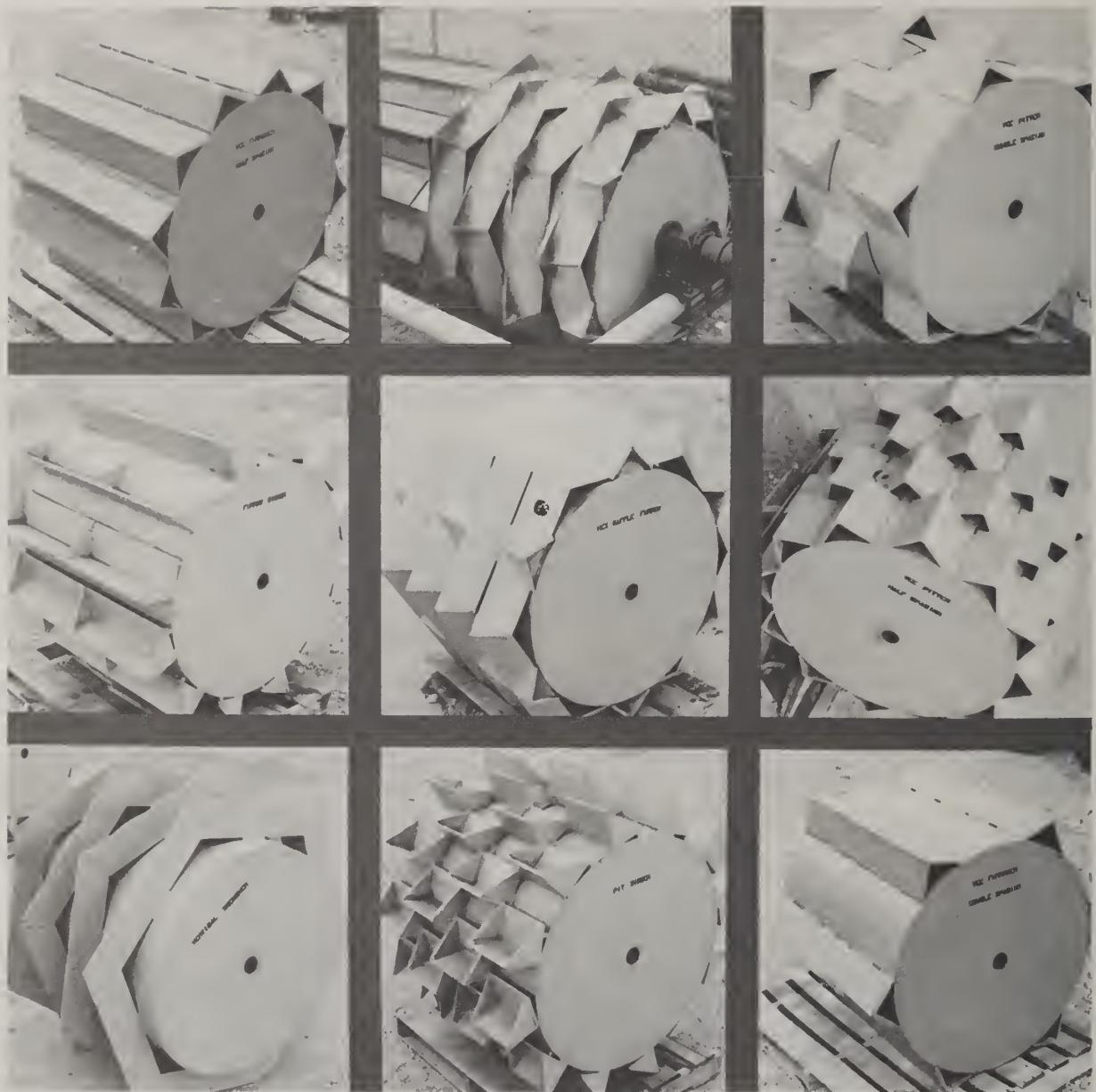
The land imprinter operates satisfactorily on rough, rocky, or brush-covered terrain and on most soil conditions. It can treat slopes up to 45 percent. The land imprinter should prove to be a versatile and valuable tool for plant establishment, erosion control, and disturbed land rehabilitation.

### Limitations

The land imprinter is not capable of treating dense stands or sprouting brush. Prior treatment is recommended for stems over 3 in (7.6 cm) in diameter. Repeated treatments may be necessary if the impressions wear down.



Dixon land imprinter with a rotary seed spreader.



*Imprint capsules available for the land imprinter.*

#### Specifications

Pattern width 6 ft 7 in (2 m)  
Drum width 3 ft 3 in (1 m)  
Drum diameter (excluding imprint patterns) 3 ft 3 in  
(1 m)  
Pattern depth to 6 in (15 cm)  
Power requirements (flywheel) 60 to 105 hp (45 to 78  
kW)

#### Availability

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

Information may be obtained from:

USDA, Science and Education Administration  
Southwest Rangeland Watershed Research Center  
442 East Seventh Ave.  
Tucson, Ariz. 85705  
(602) 792-6381  
FTS 762-6381

# Rotary Tillers

## Function

Rotary tillers are powered tillage implements for primary and secondary tillage, for incorporating soil amendments, and for breaking up sod.

## Description

Rotary tillers have a series of spikes, flails, or blades attached to a rotating horizontal shaft. The shaft is usually powered by power-take-off, but may be powered hydraulically. The implements are generally attached directly to the tractor and can be raised and lowered hydraulically.

## Techniques

As the rotary tillers are moved through the soil, they chop and mix cover crops, mulches, or other soil amend-

ments. Tilling depth can be controlled by adjusting the rotary speed.

## Capabilities

Rotary tillers are very effective in incorporating fertilizers, mulches, or manure into the soil on strip mine reclamation sites. The chopping and mixing action improves infiltration and percolation. Rotary tillers are also effective in breaking up and turning under sod.

## Limitations

Rotary tillers are limited to fairly rock-free ground and slopes under 30 percent. Power-take-off operation requires more power than conventional tillage implements.



*Rototiller conditioning the soil.*



*Rototiller blades.*

#### Specifications

Width 5 to 20 ft (1.5 to 6.1 m)  
Depth to 10 in (25 cm)  
Power-take-off (PTO) speed 1,000 rpm  
Power requirements (drawbar) 100 hp (75 kW)  
minimum

#### Availability

Australian Farm Equipment Pty., Ltd.  
1818 Westlake Ave. North

Seattle, Wash. 98109  
(206) 284-9236

Can-A-Mex Manufacturing, Ltd.  
8211 31st St. SE  
Calgary, Alta., Canada T2C 1H9  
(403) 279-7750

FMC Corp.  
Agricultural Machinery Div.  
Box 818  
Minden, La. 71055  
(318) 377-0383

Ferguson Manufacturing Co., Inc.  
Box 1098  
Suffolk, Va. 23434  
(804) 539-3409

Hakmet, Ltd.  
179 Place Frontenac  
Pointe Claire, Quebec, Canada H9R 4Z7  
(514) 694-4791

Horwood Bagshaw, Ltd.  
Box 270  
Clarence Gardens, South Australia 5039  
Australia

Howard Rotavator Co., Inc.  
Box 100  
Harvard, Ill. 60033  
(815) 943-6424

KMN Modern Farm Equip., Inc.  
12 Sullivan St.  
Westwood, N.J. 07675  
(201) 666-3707

Seaman Co.  
Box 25331  
Milwaukee, Wis. 53225  
(414) 781-8900

Utility Tool & Body Co., Inc.  
Box 360  
Clintonville, Wis. 54929  
(715) 823-3167

# Fertilizing and Mulching

The equipment in this section distributes dry fertilizer, manure, granular and pelletized chemicals, lime, or fiber mulch. Liquid material is distributed with sprayers or subsoil injectors, discussed under the *Controlling Plants with Chemicals* section. Aerial applicators, hydraulic seeder-mulchers, and small broadcast spreaders, covered under the *Seeding* section, may also distribute certain chemicals or mulch.

Fertilizers are added to the soil to provide adequate nutrients for establishing plants. The amount of fertilizer required, usually nitrogen, phosphorous, and sulfur, is determined by previous soil testing. Organic material, such as manure or straw mulch, improves soil structure. However, seeding should be deferred for 2 to 4 weeks following the application of organic material because the action of soil micro-organisms creates a temporary deficiency of available nitrogen.

Lime is sometimes added to the soil to reduce acidity. Granular or pelletized herbicides and insecticides reduce competition from weeds and control harmful insects.

Mulches are often spread over seeded areas to retain moisture and provide shelter for newly established seedlings. They help prevent erosion, direct infiltration, and reduce evaporation on areas with limited rainfall. Mulches are particularly useful on harsh arid sites or steep slopes.

Soil amendments provide the necessary conditions for good plant growth and vigor. They should be considered for depleted lands, eroded watersheds, or reclamation areas to help insure successful revegetation.

## Fertilizer Spreaders

### Function

Fertilizer spreaders distribute dry materials, such as fertilizer or lime, over an area. They have large capacities and adjust for a wide variety of application rates.

### Description

Fertilizer spreaders are usually mounted on trailers, trucks, or high flotation equipment. They have large hoppers with sloped sides. The sides converge on a steel mesh or rubber conveyor belt that moves the material to the rear of the hopper and drops it onto one or two rotating, bladed disks, or spinners. The spinners and conveyor belt are usually powered hydraulically or with power-take-off (PTO) from a tractor. The conveyor belt is sometimes wheel-driven. Agitators placed above the conveyor belt insure a continuous flow of material.

### Techniques

The fertilizer spreaders are driven or pulled over the area to be treated. The application rate is controlled by the size of the rear hopper opening or the speed of the conveyor belt. The spinner speed is kept constant for even distribution over the swath.

### Capabilities

Fertilizer spreaders can distribute most types of dry soil amendments. Smaller spreaders may be used to broadcast seed. Fertilizer spreaders have large capacities and are adjustable over a wide range of spreading rates.

### Limitations

Fertilizer spreaders are not suited to brushy, rough, or very steep land. They are most useful where amendments are spread rapidly over large areas.



*Truck-mounted fertilizer spreader.*



*Trailer-mounted fertilizer spreader with a wheel-driven belt.*

## Specifications

### Trailer-mounted:

Pattern width 40 to 80 ft (12 to 24 m)  
Hopper capacity 35 to 280 cu ft (991 to 7928 l)  
1 to 8 tons (.9 to 7.3 metric tons)

### High flotation or truck-mounted:

Pattern width 24 to 60 ft (7.3 to 18.3 m)  
Hopper capacity 5 to 14 cu yd (3.8 to 10.7 kl)  
5 to 17 tons (4.5 to 15.4 metric tons)

## Availability

### Trailer-Mounted:

Australian Farm Equipment Pty., Ltd.  
1818 Westlake Ave. North  
Seattle, Wash. 98109  
(206) 284-9236

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Hahn, Inc.  
1625 North Garvin  
Evansville, Ind. 47711  
(812) 424-0931

Horwood Bagshaw, Ltd.  
Box 270  
Clarence Gardens, South Australia 5039  
Australia

Lakeside Truck Body Co.  
Box 1104  
Turlock, Calif. 95380  
(209) 632-7501

Larson Machine, Inc.  
Box 308  
Princeville, Ill. 61559  
(309) 385-4312

John Blue Co.  
Box 1607  
Huntsville, Ala. 35807  
(204) 536-5581

Tyler Div.  
TCI, Inc.  
Benson, Minn. 56215  
(612) 843-3333

United Farm Tools, Inc.  
Box 9175  
South Charleston, W. Va. 25309  
(304) 768-8221

Vicon Farm Machinery, Inc.  
3741 Cook Blvd.  
Chesapeake, Va. 23323  
(804) 485-1600

Wilmar Manufacturing Co.  
Box 957  
Wilmar, Minn. 56201  
(612) 235-0767

### High Flotation or Truck-Mounted:

Ag Chem Equipment Co.  
4900 Viking Dr.  
Minneapolis, Minn. 55435  
(612) 835-2476

Big Wheels, Inc.  
Box 113  
Paxton, Ill. 60957  
(217) 379-2369

Dempster Industries, Inc.  
Box 848  
Beatrice, Nebr. 68310  
(402) 223-4026

Henderson Manufacturing Co.  
Box 40  
Manchester, Iowa 52057  
(319) 927-2828

Highway Equipment Co.  
616 D Ave. NW  
Cedar Rapids, Iowa 52405  
(319) 363-8281

John Blue Co.  
Box 1607  
Huntsville, Ala. 35807  
(205) 536-5581

Lakeside Truck Body Co.  
Box 1104  
Turlock, Calif. 95380  
(209) 632-7501

Rickel Manufacturing Co.  
Box 626  
Salina, Kans. 67401  
(913) 825-1631

Tryco Manufacturing Co.  
Box 1277  
Decatur, Ill. 62525  
(217) 428-0901

Tyler Div.  
TCI, Inc.  
Benson, Minn. 56215  
(612) 843-3333

Wilmar Manufacturing Co.  
Box 957  
Wilmar, Minn. 56201  
(612) 235-0767

# Granular Applicators

## Function

Granular applicators broadcast seed, fertilizer, or granular chemicals in closely spaced rows behind a tractor. They are available in side-wheel models or they may be mounted on tillage implements.

## Description

Granular applicators are wide hoppers with holes in the bottom. Tubes lead down from the holes on hoppers mounted on implements so the material is distributed close to the ground. An agitator inside the hopper meters the flow of material. The agitator is usually driven by the running gear.

## Techniques

Granular applicators are often mounted on tillage implements. The broadcast chemicals are then immediately incorporated into the soil. When mounted on brush control implements, granular applicators can seed areas too rough for drilling. Combination seed and fertilizer hoppers may be mounted on disk harrows for once-over treatment of some agricultural land. Herbicides may be broadcast over low vegetation or stands of poisonous forbs by granular applicators.

## Capabilities

Granular applicators allow precise and uniform application of material. The material is applied close to the ground to eliminate drift and excessive particle movement during application.

Implement-mounted granular applicators may combine two or more operations into a single treatment.

## Limitations

Most granular applicators can operate only on relatively even terrain. Broadcast materials remain subject to movement by wind and water unless they are quickly covered or worked into the soil. Drill seeding is usually preferable to broadcast seeding where conditions permit.



*Side-wheel granular applicator.*



*Seed and fertilizer applicators mounted on one-way disk harrows.*

## Specifications

Width 3 ft to 48 ft (.9 to 14.6 m)  
Hopper capacity 5 to 47 cu ft (142 to 1330 l)  
300 to 2000 lb (136 to 907 kg)

## Availability

AVCO  
EXEE Flow  
First and Sycamore St.  
Coldwater, Ohio 45828  
(419) 678-5396

Barber Engineering Co.  
North 1404 Regal  
Spokane, Wash. 99202  
(509) 534-9460

Beline Manufacturing Co., Ltd.  
Box 1840  
Kindersley, Sask., S0L 1S0, Canada  
(306) 463-2604

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Farnum Equipment Co.  
Box 21447  
Phoenix, Ariz. 85036  
(602) 244-8261

Gandy Co.  
528 Gandrud Rd.  
Owatonna, Minn. 55060  
(507) 451-5430

Massey-Ferguson, Inc.  
1901 Bell Ave.  
Des Moines, Iowa 50315  
(515) 247-2011

Napier Grasslands Pty., Ltd.  
Box 244  
Taree, NSW, 2430  
Australia

Spierco Industries, Ltd.  
727 42nd Ave. SE  
Calgary, Alt., T2G 1Y8, Canada  
(403) 243-7772

United Farm Tools, Inc.  
Box 9175  
South Charleston, W.Va. 25309  
(304) 768-8221

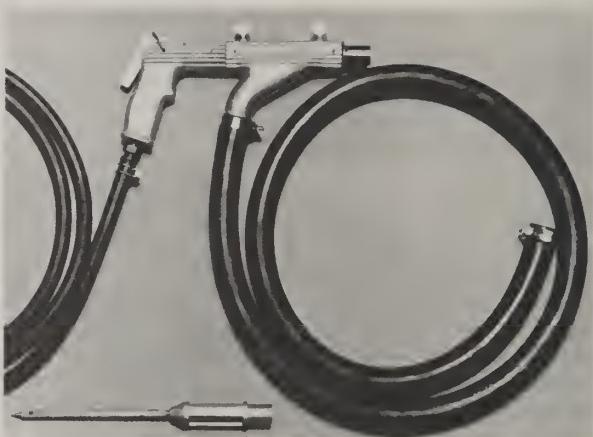
## Fertilizer Blasting Gun

### Function

The fertilizer blasting gun distributes granular or pelletized chemicals with blasts of compressed air. The device may also treat spots of individual trees or shrubs from a vehicle.

### Description

The fertilizer blasting gun is hand-held and connects to a portable air compressor with a 12-ft (3.7 m) air hose. A 7-ft (2.1 m), static-resistant suction hose, 1 in (2.5 cm) in diameter, feeds the chemical to the air gun. The gun and trigger mechanism are aluminum alloy casting and the blast nozzle is chrome alloy, hardened steel for greater durability.



*Fertilizer blasting gun.*

### Techniques

The fertilizer blasting gun is generally operated from a vehicle that transports the compressor, the chemical material, and one or two operators. The compressor should maintain a pressure of 90 to 100 lb/in<sup>2</sup> (620-689 kPa) to allow the granules or pellets to be sprayed up to 75 ft (23 m). Timed air blasts and previous calibration can provide some control of the application rate.

### Capabilities

Steep, rough terrain or confined areas can be effectively treated. The fertilizer blasting gun may also prove useful for spot treatments of individual plants or small stands. The stream of material should easily penetrate dense growth.

### Limitations

The application rate may be difficult to control precisely. The amount of material dispensed, as well as the distance covered, decrease if the air pressure drops below 90 lb/in<sup>2</sup> (620 kPa). Granular or pelletized chemicals require rainfall for activation. The material may be displaced by strong winds or heavy rain.

### Specifications

Range to 75 ft (23 m)  
Air pressure 90 to 100 lb/in<sup>2</sup> (620 to 689 kPa)  
Air volume 50 to 60 cu ft/min (1.4 to 1.7 kl/min)  
Weight 14 lb (6.4 kg)

### Availability

Federal Brass Manufacturing Co.  
Box 60  
Corning, N.Y. 14830  
(607) 732-6620

# Manure Spreaders

## Function

Manure spreaders are used to distribute heavy solids over an area. The material is usually incorporated into the soil as a conditioner.

## Description

Manure spreaders are large, open trailers or trucks with conveyor beds. The spreading mechanisms, located at the rear of the spreaders consist of beaters, paddles, or flails. The spreading mechanisms rotate at moderate speeds, forcibly ejecting the material. The spreading mechanisms and conveyor beds are usually powered through power-take-off attachments. Auxiliary beaters are often located above the spreading mechanisms to aid the flow of material through the spreaders. A modified manure spreader has been specially developed to distribute mulch over strip-mined land.

## Techniques

The spreaders are towed or driven over the area to be treated. The conveyor moves the material to the rear of the spreaders where it is ejected by the rotating beaters, paddles, or flails. Discharge rates can be varied by adjusting the speed of the conveyor bed.

## Capabilities

Manure spreaders are designed to efficiently distribute manure or straw mulch. This material is used to condition the soil by increasing the amount of organic matter and nutrients and improving the structure. This is especially useful in reclaiming strip-mined lands.

## Limitations

The operation of manure spreaders is limited to level ground or moderate slopes. Due to the action of soil micro-organisms, nitrogen deficiencies occur in the soil for a brief period following the application of organic materials.



*Standard manure spreader.*



*Manure spreader modified to apply straw mulch.*

### Specifications

#### Capacity:

64 to 360 cu ft (1.8 to 10.1 kl) level full

2.8 to 18 tons (2.5 to 16.3 metric tons)

Overall width 6 ft 6½ in to 11 ft (2 to 3.4 m)

Power requirements (drawbar) 30 hp (22.4 kW)  
minimum

### Availability

#### Manure Spreaders:

#### AVCO

New Idea Farm Equipment  
420 South First St.  
Coldwater, Ohio 45828  
(419) 678-5311

Big Wheels, Inc.  
Box 113  
Paxton, Ill. 60957  
(217) 379-2369

Blair Manufacturing Co.  
929 East Washington  
Blair, Nebr. 68008  
(402) 426-2151

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Du-Al Manufacturing Co.  
1000 West Cherokee St.  
Sioux Falls, S. Dak. 57104  
(605) 336-3869

Farmhand, Inc.  
525 15th Ave. South  
Hopkins, Minn. 55343  
(612) 938-7651

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 643-2000

Gehl Co.  
143 East Water St.  
West Bend, Wis. 53095  
(414) 334-9461

Hawk Bilt Co.  
402 East 6th St.  
Vinton, Iowa 52349  
(319) 472-2313

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-3874

New Idea Farm Equipment  
Coldwater, Ohio 45828  
(203) 552-1800

Schultz Manufacturing Co.  
Box 388  
Waterloo, Iowa 50704  
(319) 234-7578

Schwartz Manufacturing Co.  
Box 248  
Lester Prairie, Minn. 55354  
(612) 395-2541

Sperry New Holland  
500 Diller Ave.  
New Holland, Pa. 17557  
(717) 354-1121

United Farm Tools, Inc.  
Box 9175  
South Charleston, W. Va. 25309  
(304) 768-8221

#### Modified Mulch Spreader:

Drawings (No. 611) and information  
can be obtained from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

## Modified StakProcessor

### Function

A Hesston StakProcessor has been modified with a flail device to distribute straw mulch from 1,500-pound (680 kg) round bales. The straw mulch is spread over strip mine reclamation areas.



Hesston stakprocessor with MacFarlane flail to distribute straw mulch from round bales.

### Description

The StakProcessor was designed to lift, transport, and shred large round bales of hay and to distribute the hay in windrows for cattle feed. The implement consists of a four-tine, hydraulic-bale pickup and a power-take-off (PTO) powered shredder and auger.

The modification, or MacFarlane flail, consists of a standard hydraulic motor, with four reinforced rubber belt flails, and a stabilizer mounting bracket attached underneath the side opening of the StakProcessor. The flail hydraulics are independent of the bale pickup and allow the flail speed and direction of rotation to be controlled from the tractor.

### Techniques

The bale pickup tines slide under the bale and are tilted up, forcing the bale into the shredders. The shredders break apart the compacted straw or hay and deliver it to the auger. The auger forces the material out the side of the machine into the MacFarlane flail.

The flails intercept the material from the StakProcessor discharge and distribute the mulch over a wide area. Flail speed should vary inversely to the tractor speed for uniform distribution. Flail direction is clockwise except when strong winds are blowing from the rear of the unit or into the discharge chute.

### Capabilities

Picking up and distributing large round bales becomes a simple, one-person task with the modified StakProcessor. The speed and directional control of the flail unit allows uniform distribution of straw mulch under most conditions.

### Limitations

The modified StakProcessor is not suited for steep or very rough terrain. The mulch should be incorporated into the ground or otherwise anchored to keep it in place.



MacFarlane flail.

### Specifications

|   |
|---|
| Capacity 3,000 lb (1,360 kg)                          |
| Flail speed 100 to 1,000 rpm                          |
| Power-take-off (PTO) speed 540 rpm                    |
| Power requirements (drawbar) 40 hp<br>(30 kW) minimum |

### Availability

StakProcessor:

Hesston Corp.  
Box 788  
Hesston, Kans. 67062  
(316) 327-4000

### MacFarlane Flail:

Information may be obtained from:

Western Energy Co.  
Box 67  
Colstrip, Mont. 59323  
(406) 748-2366

## Power Mulchers

### Function

Power mulchers blow dry fiber mulch, mostly straw and hay, onto treatment areas to increase moisture holding ability, enhance seed germination and growth, and reduce erosion.

### Description

A power mulcher blows dry fiber mulch with air pressure generated by a motor-driven, high pressure fan. The mulcher has an adjustable-height loading chute with either gravity feed or variable speed conveyor feed. The blower mechanism consists of rotary beaters to break up the mulch, a paddlewheel fan to generate pressure, and a discharge chute. An adhesive injector nozzle may be attached to the mouth of the discharge chute. The chute can rotate in a full circle horizontally, and up to 70 degrees vertically.

### Techniques

Bales of mulch are transported on the mulcher's prime mover and placed on the loading chute one at a time. They either slide or are conveyed into the chamber with the rotary beater. The rotary beater breaks the bales apart and separates the mulch fibers. The mulch fibers are then sucked into a fan and blown out the discharge chute directed towards the slope. An adhesive can be atomized in the airstream and combined with the mulch fibers, so the mulch is tacked to the ground surface and held stable. The mulch may be incorporated into the soil mechanically if adhesives are not applied.

### Capabilities

Power mulchers provide the ability to cover inaccessible slopes with self-attaching mulch from a nearby bench or road. The mulchers can use any long-fiber dry mulch, but not all mulches produce similar results.

### Limitations

Small light materials, such as sawdust, are difficult to blow far and are subject to drift. Heavy materials, such as large wood chips or bark, will not carry far in the airstream and tend to tear up the beater and fan mechanisms. An impactor is needed to propel heavy mulches.



*Typical power mulcher.*



*Power mulcher treating a steep slope.*

### Specifications

Spread rates to 15 tons/hour (13.6 metric tons/hr)  
Spread distance to 70 ft (21 m)  
Adhesive pump capacity to 50 gal/min (189 l/min)  
Power ratings 30 to 109 hp (22 to 81 kW)

### Availability

Finn Equipment Co.  
2525 Duck Creek Rd.  
Cincinnati, Ohio 45208  
(513) 871-2529

Reinco, Inc.  
Box 584  
Plainfield, N.J. 07061  
(201) 755-0921

# Estes Blower Spreader

## Function

The Estes blower spreader applies solid soil amendments such as lime, fertilizer, shredded bark, wood chips, or seed, to steep slopes. The amendments, singly or in combination, can be blown 75 ft (23 m) up or down a 60-degree slope and up to 125 ft (38 m) horizontally.

## Description

The Estes blower spreader is a blower/impactor that attaches to the hopper of a large, truck-mounted rotary spreader. The conveyor within the hopper transports the amendments into a blower/impactor mechanism that consists of a large fan driven by a separate gasoline engine. A hydraulic cylinder, operated from the cab, controls the vertical angle of the flow of the discharged materials. Spinners, such as those of most rotary spreaders, can accompany the Estes spreader to distribute amendments near the truck.

## Techniques

The Estes blower spreader is driven along a road, terrace, or bench above or below the slope to be treated. The amendments are blown up or down slope from the truck. The hydraulic direction control allows adequate coverage of changing slopes. Application rates are determined by the speed of the truck and the blower speed. Level ground may be treated using the blower, spinners, or both. To fully cover an area, the spinners are needed to spread close to the truck.

## Capabilities

The Estes blower spreader is useful for roadside stabilization or strip-mine reclamation. It enables liming, fertilizing, mulching, and seeding of steep slopes without water, which is required for hydroseeding and hydromulching. Steep slopes are also treated without mechanical disturbance.

## Limitations

The Estes blower spreader is limited to accessible areas. Wind affects the distribution of light materials such as seed or powdered chemicals. Heavier materials tend to carry farther, resulting in uneven distribution of materials with different weights. A safety problem is presented when large chunks of hard material are ejected from the blower at high velocity.



*The Estes spreader.*

## Specifications

Spread width (blower spreads only on the left side of the vehicle) 75 ft (23 m) on 60-degree slope  
125 ft (38 m) on level ground  
Spinners to 40 ft (12 m)  
Power rating 56 hp (41 kW)

## Availability

Estes Equipment, Inc.  
Route 4, Bybee Rd.  
Winchester, Ky. 40391  
(606) 744-5900

# Finn Krimper

## Function

The Finn Krimper anchors straw or long fiber mulch by partially incorporating it into the soil. The fiber ends extend vertically from the soil, much like crop stubble.

## Description

The Finn Krimper consists of a series of 20-in (51 cm) disks spaced 8 in (20 cm) apart along a horizontal axle. The axle is attached to a heavy frame equipped with steel boxes. The boxes can be filled with rocks for additional weight. The Finn Krimper may be mounted on a three-point hitch or towed. Wheels are available that can be raised and lowered hydraulically for transport. Disk scrapers are standard.

## Techniques

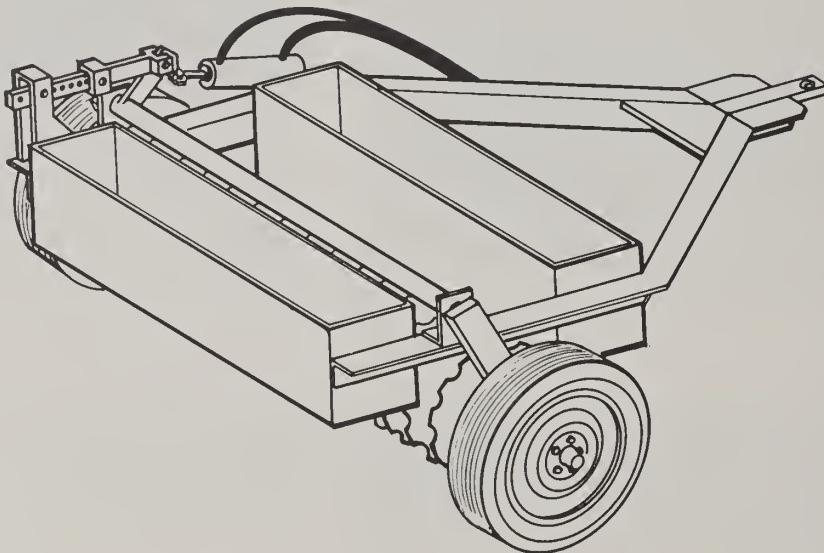
The disks roll parallel to the direction of travel, cutting narrow grooves in the soil. Some of the mulch fibers are punched into these grooves, thereby anchoring the mulch to the soil surface.

## Capabilities

The Finn Krimper incorporates mulch fibers vertically into the soil. The protruding mulch fibers act as crop stubble to help prevent wind erosion and direct infiltration.

## Limitations

The Finn Krimper should be operated on the contour to prevent water erosion in the grooves. Breakage may occur in rocky areas.



*The Finn Krimper.*

### Specifications

Width 6 or 8 ft (1.8 to 2.4 m)  
Depth 1 to 3 in (2.5 to 7.6 cm)  
Weight 1,000 to 1,300 lb (454 to 590 kg)  
Power requirements (drawbar) 20 to 50 hp (15 to 37 kW)

### Availability

Finn Equipment Co.  
2525 Duck Creek Rd.  
Cincinnati, Ohio 45208  
(513) 871-2529

## Final Seedbed Preparation

This section includes secondary tillage and soil packing equipment for incorporating soil amendments, preparing the finished seedbed, or covering broadcast seed. Equipment suitable for mechanical control as well as seed covering, such as chains, cables, rails, or pipe harrows, is included in the *Controlling Plants with Equipment* section.

The finished seedbed should be smooth and free from unwanted plant competition. Secondary tillage pulverizes the soil surface and destroys most weeds. Fertilizer, manure, lime, pre-emergency herbicide, insecticide, or mulch may be distributed over the area and incorporated during secondary tillage. A rough seedbed will

hold more water and reduce wind damage better than a smooth seedbed.

For maximum germination and growth, seed should be placed at the proper depth in the soil. The seedbed should be firm beneath the seed zone and well pulverized above. This provides optimum substrate conditions and moisture availability for establishing plants. Broadcast seed should be covered with a uniform layer of firm soil to promote seed germination and seedling growth. Because seed placement is so important, drilling or planting is preferable to broadcast seeding on most areas where field finishing equipment can operate. Smooth seedbeds contribute to efficient drill operation.

### Soil Sifters

#### Function

Soil sifters clean fields by removing roots, rocks, and brush from the soil and depositing the material in windrows. A self-powered model attaches directly to a rootplow to accomplish once-over brush control and seedbed preparation.

#### Description

Two models of soil sifters are available. One model is self-powered and attaches to a standard rootplow. It consists of an inclined row of five rotating beaters and a rear brush storage bin. The beaters are driven by a separate diesel engine. A hydraulic drive is being developed for greater reliability. The brush storage bin has a dump gate operated from the tractor either hydraulically or by a cable.

Another model is powered with power-take-off (PTO) from a wheeled tractor. It is mounted on the draft arms of a three-point hitch. This model has three rotating, toothed cylinders and an inclined, steel-mesh conveyor belt. It features hydraulic control of the operating depth and of the storage bin dump mechanism.

Both soil sifters are supported by rear wheels.

#### Techniques

With the self-powered model, the soil and brush are removed and lifted onto the beaters by the rootplow. The beaters shuffle the roots and brush to the rear storage bin while the soil is shaken loose to drop back to the ground. The brush accumulated in the storage bin is dumped into windrows by carefully timed applications of the dump gate mechanism.

Operation of the PTO model is similar except that the ground is prepared with a chisel plow or disk plow prior to cleaning. The beaters comb the soil and deposit the debris on the conveyor belt. The large size material is conveyed to the storage bin to be piled into windrows.

#### Capabilities

Soil sifter treatments result in smooth, well-pulverized seedbeds. The windrows of brush contain little soil and can be easily burned or removed, leaving the area suitable for seeding. The self-powered system can control sprouting brush and prepare a clean seedbed with a single pass over the area.

#### Limitations

The area must be quickly seeded to prevent erosion, and reinvansion by brush or weeds. Rootplows should be operated below the resprouting zone of the shrubs. The PTO model usually requires previous ground treatment for efficient operation. The sifters are not adapted to very rocky soils.



Stacko soil sifter showing rows of beaters.



Brush bin on Stacko soil sifter.



Soil sifter with chain conveyor.

## Specifications

### Self-powered model:

Width 7 ft 2 in to 16 ft 2 in (2.2 to 4.9 m)

Depth to 36 in (91 cm)

Power ratings (flywheel) 146 hp (109 kW)

### Power-take-off (PTO) model:

Width 8 ft (3.2 m)

Depth to 12 in (30 cm)

Power-take-off (PTO) speed 1,000 rpm

Power requirements (drawbar) 100 hp (75 kW)

## Availability

### Self-powered model:

W. A. Arnord and Sons

Drawer B

Three Rivers, Tex. 78071

(512) 786-2651 or (512) 786-3387

### Power-take-off (PTO) model:

Rockland Manufacturing Co.

Box 5

Bedford, Pa. 15522

(814) 623-1115

# Disk Harrows

## Function

Disk harrows are for secondary tillage and for incorporating mulches and other amendments into the soil. They are sometimes used for primary tillage.

## Description

Disk harrows consist of two or four gangs of small disks offset to thoroughly mix the soil by moving it in opposite directions. Although some disk harrows mount directly on the tractor, most are towed implements with wheels that can be raised and lowered hydraulically. Many disk harrows have folding frames for easy transport.

## Techniques

Disk harrows are towed over rough plowed or fallow land for final seedbed preparation. They can also chop and mix mulch or chemicals into the soil. Larger disk harrows can be used for primary tillage where conditions permit.

## Capabilities

Disk harrows are versatile implements for tillage, turning under mulch, and incorporating soil amendments. They can also control annuals on level, rock-free ground.

## Limitations

Disk harrows are not well suited to rough, rocky, or brushy areas. They can often chop through light trash, but disks may break when more extreme conditions are encountered.



*Disk harrow.*

## Specifications

Width 6 ft 7 in to 50 ft (2 to 15.2 m)  
Depth to 12 in (30 cm)  
Disk Diameter 18 to 26 in (46 to 66 cm)  
Weight to 594 lb per ft (884 kg/m)  
Power requirements (drawbar) 40 to 315 hp (30 to 235 kW)

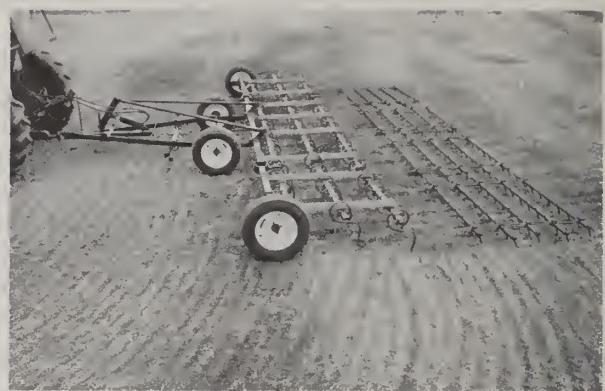
## Availability

Disk harrows are available from most farm implement manufacturers and farm equipment dealers.

# Spring Tooth Harrows and Field Cultivators

## Function

Spring tooth harrows and field cultivators are for secondary tillage, controlling annual vegetation, and incorporating soil amendments. They are well adapted to areas too rocky or trashy for effective disking.



*Spring tooth harrows used in combination with a spike tooth harrow.*

## Description

Spring tooth harrows and field cultivators resemble light-duty chisel plows. Spring tooth harrows have several flexible shanks directly attached to a frame. Field cultivators generally have sturdier shanks, spring-mounted on a frame. Interchangeable tips, ranging from wide shovels to narrow reversible chisel tips, can be attached to the shanks to produce the desired cultivating action. Wheels are usually attached to the frames to control depth. Folding or sectioned frames enable wider implements to be transported easily. Spring tooth harrows and field cultivators can be mounted on tractors or towed.



*Field cultivator with folding wings.*

## Techniques

As the spring tooth harrow or field cultivator is towed over the ground, the shanks vibrate in the soil, producing the tillage action. The shanks break up large soil chunks and mix amendments with the soil. The vibrating action effectively controls annual plants.

## Capabilities

Spring tooth harrows or field cultivators can be used for secondary tillage on moderately rocky or trashy ground. They incorporate mulch or chemicals and provide a uniform surface texture for the final seedbed. With wide shovels on the shank tips, these implements can eradicate herbaceous plants.

### Specifications

Width 3 ft 9 in to 60 ft (1.1 to 18.3 m)  
Depth to 6 in (15 cm)  
Power requirements (drawbar) 20 to 315 hp  
(15 to 235 kW)

## Limitations

Spring tooth harrows and field cultivators are not suited for rough rangeland conditions. Breakage will occur if many large rocks, heavy trash or other obstacles are encountered. Spring tooth harrows and field cultivators tend to collect brush and debris, which must be removed.

### Availability

Spring tooth harrows or field cultivators are available from most farm implement manufacturers and farm equipment dealers.

# Spike Tooth Harrows

## Function

Spike tooth harrows smooth rough-plowed land or cover broadcast seed on ground that is too trashy for drilling.

move enough soil to cover broadcast seed. They can cover seed without completely destroying cover crops. Coil spring tynes vibrate as they are moved to increase the smoothing action.

## Description

Spike tooth harrows consist of a number of short, straight teeth or coilspring tynes attached to a frame. The spikes or tynes are often set at a slight angle rearward to prevent trash buildup. Many spike tooth harrows have wheels to provide support and facilitate transport. Wide harrows have either folding frames or easily disassembled small sections.

## Capabilities

Spike tooth harrows have covered broadcast seed on trashy ground or among preparatory or cover crops. They can smooth seedbeds prior to planting or broadcasting.

## Limitations

Spike tooth harrows are not well suited to rough range-land conditions. They are somewhat ineffective in covering seed to a uniform depth. The spikes or tynes do not deeply penetrate the soil, but merely treat the surface.



*Spike tooth harrow.*

## Specifications

Width 4 to 75 ft (1.2 to 22.9 m)

Power requirements (drawbar) 20 hp (15 kW) minimum

## Availability

Brillion Iron Works  
200 Park Ave.  
Brillion, Wis. 54110  
(414) 756-2121

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Degelman Industries, Ltd.  
Box 963  
Regina, Sask., Canada S4P 3B2  
(306) 543-4447

Farm King, Ltd.  
Box 1450  
Morden, Man., Canada R0G 1J0  
(204) 822-4467

Farnum Equipment Co.  
Box 21447  
Phoenix, Ariz. 85036  
(602) 244-8261

Ferguson Manufacturing Co.  
Box 1098  
Suffolk, Va. 23434  
(804) 539-3409

Flexi-Coil, Ltd.  
Box 1928  
Saskatoon, Sask., Canada S7K 3R3

J. A. Freeman & Son, Inc.  
2034 Northwest 27th Ave.  
Portland, Oreg. 97210  
(503) 222-1971

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-2000

Kewanee Machinery Div.  
Chromalloy America Corp.  
1516 Burlington Ave.  
Kewanee, Ill. 61443  
(309) 852-2191

Lear Siegler  
Noble Div.  
515 North 16th  
Sac City, Iowa 50583  
(712) 662-4731

McFarlane Manufacturing Co., Inc.  
1259 Water St.  
Sauk City, Wis. 53583  
(608) 643-3321

Melroe Division Ag. Products  
Clark Equipment Co.  
Box 1215  
Bismarck, N.Dak. 58501  
(701) 222-5000

Northern Wisconsin Mfg. Co.  
Box 158  
Pepin, Wis. 54759  
(715) 442-4111

United Farm Tools, Inc.  
Box 9175  
South Charleston, W.Va. 25309  
(304) 768-8221

# Klobbuster

## Function

The klobbuster is an implement that prepares steep slopes for seeding without putting a prime mover on the slopes.

## Description

The klobbuster consists of a 10 ft (3 m) length of lead chain, four 10 ft (3 m) lengths of pick chain, and a slope wheel, connected by swivels. The lead chain is a section of heavy-duty chain that is attached to a truck or tractor. Pairs of 6-in (15 cm) hardened steel picks are welded at right angles to the pick chain at 8-in (20 cm) intervals. The slope wheel has a 500-lb (227 kg) weight attached. The weight of the slope wheel can be varied to adjust the angle of pull across the slope.

## Techniques

The lead chain is attached to a truck or tractor operating on a road or bench above the slope. The klobbuster is dragged across the slope, breaking up the soil surface, leveling humps, and filling in gullies caused by erosion. It creates a slope with a uniform surface. Two to four passes usually give the desired surface texture. Many microsites are created where broadcast seed is easily trapped. Lengths of lead chains can be added to extend the working distance of the klobbuster to as much as 160 ft (49 m). Long slopes should be treated from top to bottom to erase any groove caused by the slope wheels.

## Capabilities

The klobbuster prepares a seedbed that is well suited to broadcast or hydraulic seeding, without using a prime mover on the slope. It can erase small scale erosion damage and produce a smooth, uniform surface. The klobbuster also removes sparse, unwanted plant growth from the slopes.

## Limitations

The klobbuster is not effective on slopes under 20 percent or at speeds less than 5 mph (8 km). It does not prepare a good seedbed on rocky or very compact soils. The slopes should be free from stumps, large rocks, or other obstructions, to prevent undue strain on the swivels, which may result in separation. The klobbuster exerts a considerable side draft on the prime mover.



*Klobbuster showing pick chains, lead chain, slope wheel, and weight.*



*Klobbuster being dragged along a roadside slope.*

### Specifications

Length 40 ft (12 m) extensions to 160 ft (49 m)  
Weight 970 lb (440 kg)  
Power requirements - klobbuster easily attaches to most trucks or tractors

### Availability

Finn Equipment Co.  
2525 Duck Creek Rd.  
Cincinnati, Ohio 45208  
(513) 871-2529

## Standard Cultipackers

### Function

Standard cultipackers firm seedbeds prior to planting and cover broadcast seed. They are often combined with other tillage implements or seed broadcasters.

### Description

Standard cultipackers have rollers with grooves or spikes spaced along a long horizontal axle at regular intervals. The axle is attached to a heavy frame. The rollers are interchangeable and may be replaced with different types. Some cultipackers are mounted to the front and rear of spring tooth harrows on a common frame. Additional weights can be added to some frames. Larger cultipackers and cultipacker/spring-tooth-harrow combinations have wheels for easy transport.

### Techniques

Standard cultipackers roll over the ground, to pack the soil and create a firm seedbed. They are often pulled in tandem with other implements. They are sometimes operated both before and after seeding.

### Capabilities

Standard cultipackers break up clods and firm the seedbed to improve moisture availability and insure adequate seed contact with the soil.

### Limitations

Standard cultipackers are generally limited to agricultural use. They are poorly adapted to rough, rocky, steep, or brushy terrain.



*Standard cultipacker.*



*Cultipacker with a spring tooth harrow.*

### Specifications

Width 4 ft to 32 ft 8 in (1.2 to 10 m)  
Roller diameter 15 to 20 in (38 to 51 cm)  
Power requirements (drawbar) 20 hp (15 kW)  
minimum

### Availability

#### Standard Cultipackers:

Brillion Iron Works  
200 Park Ave.  
Brillion, Wis. 54110  
(414) 756-2121

J. A. Freeman & Son, Inc.  
2034 Northwest 27th Ave.  
Portland, Oreg. 97210  
(503) 222-1971

Melroe Div. Ag. Products  
Box 1215  
Bismarck, N.Dak. 58501  
(701) 222-5000

#### Western Land Roller

Box 668  
Hastings, Nebr. 68901  
(402) 463-1306

#### Cultipacker/Spring tooth harrow combinations:

Brillion Iron Works  
200 Park Ave.  
Brillion, Wis. 54110  
(414) 756-2121

Deere & Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-3874

Kewanee Machinery Div.  
Chromalloy America Corp.  
1516 Burlington Ave.  
Kewanee, Ill. 61443  
(309) 852-2191

Western Land Roller  
Box 668  
Hastings, Nebr. 68901  
(402) 463-1306

## Flexible Cultipackers

### Function

The flexible cultipacker was designed to pack moderately rocky or uneven ground. It can firm seedbeds before planting or cover broadcast seed.

### Description

Flexible cultipackers consist of individual toothed rings or truck tires placed together along a horizontal shaft or tube. The individual rings can follow uneven ground and roll over rocks without changing the frame alignment. The tubes can be filled with water for more weight and better performance.

### Techniques

The flexible cultipacker is towed over the ground to firm the seedbed or cover seed. The individual rings or tires follow the contour of the ground. Flexible cultipackers are usually used in combination with other implements.

### Capabilities

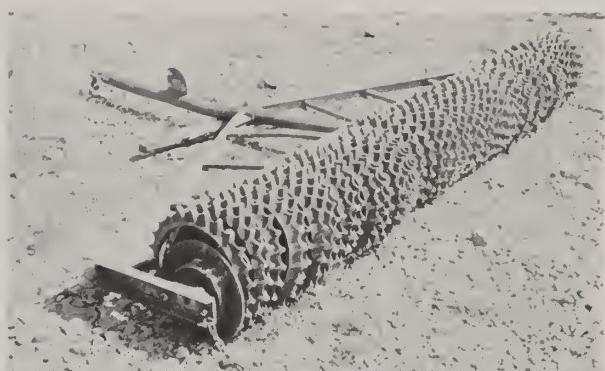
The loosely suspended rings or tires enable the flexible cultipacker to pack rough, moderately rocky ground. The packing smooths the soil and firms the seedbed for improved moisture retention near the soil surface.

### Limitations

The full weight of the implement is not distributed evenly among the rings or truck tires. Uniform compaction or seed covering may be difficult to achieve.

### Specifications

Width 2 to 24 ft (.6 to 7.3 m) in single units  
to 50 ft (15 m) in gangs  
Ring Diameter 10 to 24 in (25 to 64 cm)  
Tires 10 x 20 (25 x 51 cm)  
Tube diameter 8 to 14 (20 to 36 cm)  
Power requirements (drawbar) 20 hp (15 kW)  
minimum



*Flexible cultipacker with steel rings.*



*Flexible auto-tire cultipacker.*



*Flexible cultipacker with large steel rings.*

### Availability

#### Toothed ring models:

|   |   |
|---|---|
| Allis Chalmers<br>Agr. Equipment Div.<br>Box 512<br>Milwaukee, Wis. 53201<br>(414) 475-2000 | T. G. Schmeiser Co., Inc.<br>Box 1047<br>Fresno, Calif. 93714<br>(209) 268-8128 |
|---|---|

#### Truck tire model:

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

## Auto Tire Compaction Unit

### Function

The auto tire compaction unit firms seedbeds and covers seed on rangelands. It is designed for rough terrain.

### Description

The auto tire compaction unit consists of two sections. The front section has seven wheels and tires spaced 11 in (28 cm) center-to-center. The rear section has six wheels and tires with the same spacing but offset 5½ in (14 cm). The wheel and tires are independently suspended in the two heavy-duty frame sections. A separate spring and spindle for each wheel allows adjustment for even weight distribution and enables the tires and wheels to be removed easily for servicing.

### Techniques

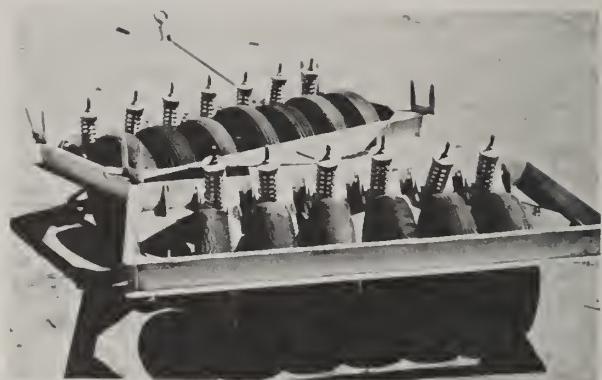
The auto tire compaction unit is towed over an area to firm the soil or cover broadcast seed. Seed broadcasters have been mounted on the unit for seeding rough, rocky terrain.

### Capabilities

The auto tire compaction unit is a rugged implement designed for rough, rocky ground. The unit packs loose soil to conserve moisture, smooths the surface, and covers seed.

### Limitations

Tire damage may result if the unit is operated on areas with many brush snags or sharp rocks. The smooth, compacted soil surface may be subject to wind or water erosion.



*Auto tire packer with independently suspended wheels.*

### Specifications

Width 7 ft (2.1 m)

Power requirements 20 hp (15 kW) minimum

### Availability

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

Drawings (RM17-01) are available from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1297 or (213) 332-6231  
FTS 793-8243

## Flexi-Coil

### Function

Flexi-coil land packers pack the soil and level the land before seeding. They can cover seed.

### Description

Flexi-coil is essentially a heavy steel coil mounted lengthwise on a horizontal axle. The coil is made of 1½ in (38 mm) or 1¾ in (44 mm) square steel. Flexi-coil is available in right and left pitches for a herringbone packing pattern. Both ball and clevis hitches are available.

### Techniques

Flexi-coil packers are usually pulled behind primary tillage equipment. The steel coils penetrate the soil and pack outward creating miniature furrows interrupted at intervals. The furrows prevent wind erosion and block water flow. Flexi-coil packers will not plug under moist conditions and have low power requirements.

### Capabilities

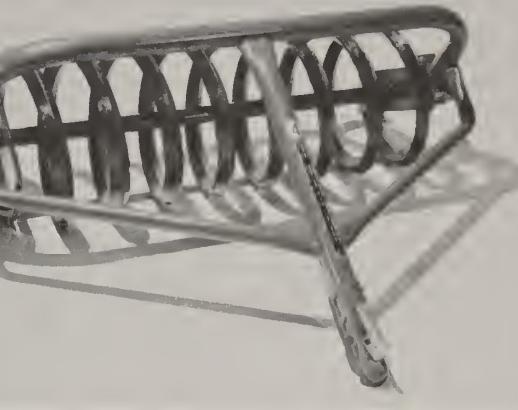
Flexi-coil packers break up large lumps of soil, level the ground surface, and seal moisture in the seedbed. They can provide small-scale erosion protection. They may cover broadcast seed.

### Limitations

Flexi-coil packers are designed for agricultural applications. They may break if used on rough or rocky land.

#### Specifications

Width 3 to 48 ft (.9 to 14.6 m)  
Weight 88 to 133 lb per ft (59 to 89 kg/m)  
Power requirements 20 to 50 hp (15 to 37 kW)



*Flexi-coil.*

#### Availability

Flexi-coil, Ltd.  
Box 1928  
Saskatoon, Sask., Canada, S7K 3S5  
(306) 652-9022



The equipment included in this section distributes seed. Interseeders provide partial seedbed preparation within established stands. The seed is either broadcast by various spreaders to scatter the seed over the ground, or planted by drills or planters to bury the seed at the desired depth. Planting the seed is the preferred method because it utilizes the available seed more efficiently, places the seed more accurately, and increases the probability of plant establishment. Broadcasting requires 50 to 75 percent more seed to obtain a stand comparable to planting.

Seeding rates should be determined prior to the seeding operation and the equipment should be carefully calibrated to deliver the desired rate. Poor seedbeds may require increased rates.

Species should be chosen to suit the requirements of the land and to fill gaps in the seasonal distribution of forage (appendix D). Mixtures should contain a few well chosen species rather than many ill-considered species, to properly achieve the goals of the reseeding program.

Seeding immediately prior to the longest growing season helps insure adequate germination and seedling growth. Grazing should be deferred until the plants are well established. Good range management will assure that the quality of the improved range is maintained. Seeding should not be substituted for improper management.

## Fixed-Wing Aircraft Spreaders

### Function

Special spreaders distribute seed or fertilizer from airplanes. High airspeeds permit rapid treatment of large areas. Aerial spreaders may work where ground machines cannot operate efficiently.

### Description

Aerial spreaders are either rotary spreaders or venturi-type, ram-air spreaders. Both systems have a hopper inside the fuselage with a sliding gate that is operated from the cockpit. The application rate is controlled by opening or closing the sliding gate. An agitator within the hopper insures a continuous flow of materials. The rotary spreaders are powered hydraulically or electrically. Venturi-type spreaders use the propeller slipstream to blow the materials out the back and to the sides of the device.

### Techniques

The equipment is calibrated for the desired application rate. Overlapping swath patterns are flown over the treatment area to give fairly even coverage. Spotters

or markers are deployed to mark previously treated areas and area boundaries. The pilot should fly as low as possible to minimize drift.

The higher airspeeds of fixed-wing aircraft allow venturi-type spreaders. Rotary broadcasters are suited to slower airspeeds or lower application rates.

### Capabilities

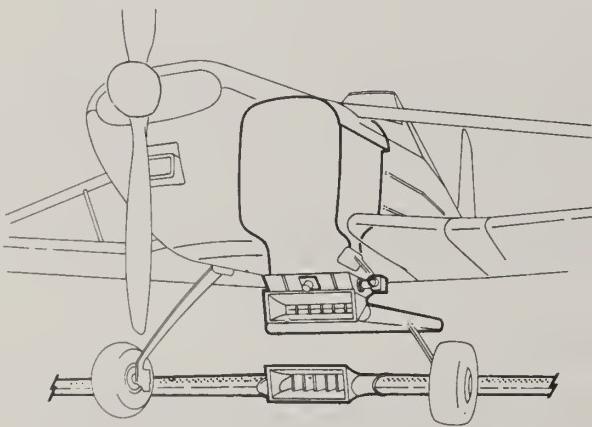
Aircraft can rapidly seed or fertilize very large areas. They quickly and effectively treat areas with slopes, soil conditions, or terrain features that limit ground equipment.

### Limitations

Airplanes require airstrips for takeoff and landing. Aerial broadcasting at high speed does not allow precise placement of broadcast materials. The broadcast material may also be moved by wind or water after application. Seed may be damaged during the operation, or destroyed by animals afterward. Also, much of the seed may be wasted because it is not placed on a micro-site that allows germination.



*Fixed-wing aircraft applying dry chemicals with a venturi-type spreader.*



*Venturi-type spreaders for airplanes.*

#### Specifications

Swath width 18 to 50 ft (5.5 to 15.2 m)  
Payload capacity 150 to 400 gal (568 to 1514 l)  
260 to 10,800 lb (118 to 4900 kg)  
Power ratings 150 to 2100 hp (112 to 1566 kW)

#### Availability

##### Contractors:

Aerial application contractors operate from many local airports.

##### Equipment:

Simplex Manufacturing Co.  
5224 Northeast 42nd Ave.  
Portland, Oreg. 97218  
(503) 281-0039

Transland, Inc.  
24511 Frampton Ave.  
Harbor City, Calif. 90710  
(213) 534-2511

# Helicopter Spreaders

## Function

Helicopter spreaders broadcast seed and granular fertilizers from the air over remote or inaccessible areas. Large, rugged areas can be treated easily with helicopters.

## Description

Most helicopter spreaders are simply rotary spreaders attached to both sides of the helicopter or suspended beneath it. The spinners are powered hydraulically from the helicopter engine or with a separate gasoline engine. Other helicopter spreaders include an aerial hydraulic seeding system and a blower spreader. Application rates are determined by the size of the hopper opening that is controlled by the pilot. The hoppers are equipped with agitators to insure a constant flow of materials. Provisions are made to quickly jettison the payload in an emergency.

## Techniques

The flow is calibrated to yield the desired application rate at a given airspeed. The pilot applies the material by carefully controlling the flow through the hopper openings. The spinners distribute the material over a broad swath. Some overlap is desirable for even distribution. The helicopter should be operated as low as possible to prevent drift. Markers or spotters are necessary for precise applications.

## Capabilities

Large, remote areas, rugged terrain, and steep slopes are easily treated with helicopters. Since they require

no landing strip, helicopters can be reloaded or refueled from a truck parked near the area. Helicopters are very maneuverable at low flying speeds.

## Limitations

Uniform distribution of materials is difficult in aircraft application. Most of the material is deposited in the center of the swath and the amount of overlap is difficult to determine accurately. In addition, the material is subject to drift and to movement after application. Seeds may be damaged during application, or destroyed afterward by animals. Much of the seed may not reach a microsite favorable for germination.



*Rotary spreader suspended beneath a helicopter.*

## Specifications

Swath width 25 to 200 ft (7.6 to 61 m)

Payload capacity:

20 to 80 cu ft (566 to 2265 l)

210 to 2200 lb (80 to 1000 kg)

Power ratings 180 to 1700 hp (139 to 1268 kW)

## Availability

### Contractors:

Aerial application contractors operate from many local airports.

### Rotary Spreaders:

Campbell Air Services, Inc.  
Box 872  
Vivian, La. 71082  
(318) 375-3207

Chadwick, Inc.  
11969 Southwest Herman Rd.  
Sherwood, Oreg. 97140  
(503) 638-8511

Evergreen Helicopters  
Three Mile Lane  
McMinnville, Oreg. 97128  
(503) 472-4151

Rambling Rotors, Inc.  
Rt. 2, Box 2744  
LaGrande, Oreg. 97850  
(503) 963-5644

Simplex Manufacturing Co.  
5224 Northeast 42nd Ave.  
Portland, Oreg. 97218  
(503) 281-0039

Transland, Inc.  
24511 Frampton Ave.  
Harbor City, Calif. 90710  
(213) 534-2511

### Hydraulic Seeding System:

AmChem Products, Inc.  
Brookside Dr.  
Ambler, Pa. 19002  
(215) 628-1000

### Blower Spreader:

Simplex Manufacturing Co.  
5224 Northeast 42nd Ave.  
Portland, Oreg. 97218  
(503) 281-0039

# Seed Dribblers

## Function

Seed dribblers seed an area from a crawler tractor during mechanical treatments. The crawler tracks distribute the seeds and press them into the soil.

## Description

Seed dribblers are small, traction-driven broadcasters that mount on a crawler tractor above the tracks. They have either fluted-force-feed or spoke-and-thimble metering mechanisms. The fluted-force-feed is similar to the metering devices in most grain drills. The spoke-and-thimble device has small cups attached to spokes that rotate through the seed in the hopper. Both metering devices are adjustable to suit the kind of seed and desired seeding rate. The traction wheels rest on and are driven by the crawler tracks.

## Techniques

Seed dribblers mount on a crawler tractor and dribble seed onto the track. The seed is carried forward on the track, dropped to the ground, and pressed into the soil by the tracks. The compacted soil provides a good, firm seedbed to hold moisture and enhance plant establishment and growth.

## Capabilities

Seed dribblers accomplish seeding during the control operation. Since the seed is pressed into the soil, problems with wind and water movement are reduced.

## Limitations

Seed placement is restricted to the crawler tracks. Several years may be required for plant cover to expand onto the adjacent areas. The tracks may also be disturbed by towed implements.

### Specifications

Hopper capacity 740 to 925 cu in (12 to 15 l)  
Seed dribblers are easily mounted on most crawler tractors.



*Thimble seeder seed dribbler.*



*Seed dribbler with fluted force feed.*

### Availability

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

Stanley G. Mitchell  
Box 241  
Fredonia, Ariz. 86022  
(602) 643-2750

# Blower Spreader

## Function

The blower spreader is designed to broadcast seed during mechanical treatment.

## Description

The blower spreader has a large rectangular box, an electrically powered fan, and a discharge chute. The seed is fed into an airstream from the seedbox and blown out the discharge chute. The unit can be mounted on trucks or tractors.

## Techniques

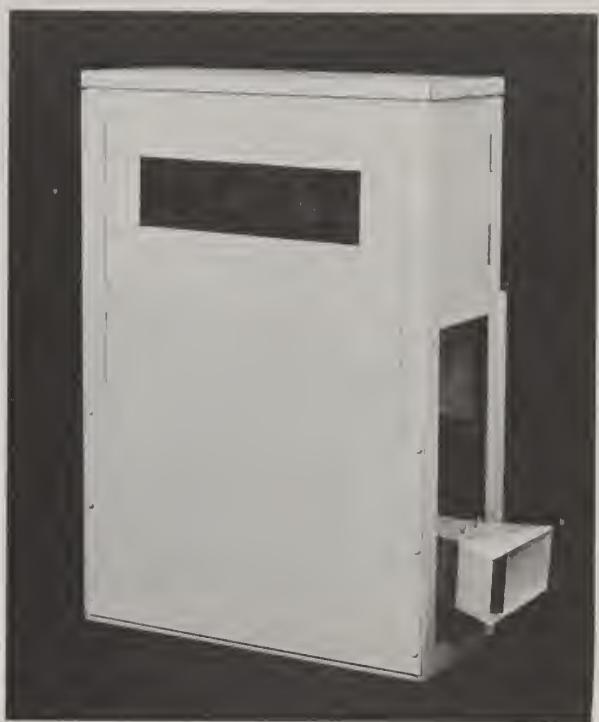
Seed is broadcast from the blower spreader while the land is being treated mechanically. The mechanical action prepares the seedbed or covers the seed. The broadcast density is adjustable.

## Capabilities

Blower spreaders are available that broadcast both fluffy and slick seed, or fluffy seed only. Uniform distribution with minimum seed damage is achieved with the blower diffuser system.

## Limitations

The light, fluffy broadcast seed may be subject to drift on windy days. Uncovered broadcast seed is subject to movement by wind or water. Drilling allows more precise seed placement.



*Blower broadcaster for fluffy and slick seed.*

## Specifications

Pattern width 12 ft (3.7 m)  
Hopper capacity 1.9 to 2.2 cu ft (53 to 62 l)  
Power supply 12 or 24 volt (dc) electrical system

## Availability

Holt Machinery Co.  
Box 658  
San Antonio, Tex. 78293  
(512) 648-1111

## Hydraulic Seeder -Mulchers

### Function

Hydraulic seeder-mulchers can apply seed, fertilizer, and soil amendments, including wood fiber mulch, in a hydraulic spray. They provide a method of seeding and mulching steep slopes without operating a prime mover on the slopes.

### Description

Hydraulic seeder-mulchers consist of a tank, a pump powered by a separate engine, and a discharge nozzle assembly. The tanks are equipped with various types of agitators to assure uniform mixtures. Large centrifugal pumps can spray the mixtures up to 200 ft (61 m) and have particle clearances of up to 1½ in (3.8 cm). Interchangeable discharge nozzles provide a variety of spray patterns. The nozzle assemblies can rotate a full 360 degrees horizontally and from 120 to 180 degrees vertically to provide complete coverage. Hydraulic seeder-mulchers may be mounted on either a trailer or truck frame.

### Techniques

The tank is filled with a slurry containing 3 to 6 percent solids by weight. The operator sprays the mixture over the area, controlling the spray pressure and volume. The hydraulic seeder-mulcher can be operated while stationary or moving. A separate hand-held hose is available for small-scale or spot treatments.

### Capabilities

Hydraulic seeding is a fast, efficient method of large-scale seeding in steep, hard-to-reach areas. Application rates may be varied to suit conditions. Mulch can be applied to increase moisture-holding capability and reduce erosion.

### Limitations

Hydraulic seeding or mulching demands large amounts of water, which may not be readily available. Seeding and mulching should be done in separate operations so the seed is not held off the ground by the mulch fibers. Many seeds may be damaged by the agitators and pumps.



Hydraulic seeder-mulcher.



Trailer-mounted hydraulic seeder-mulcher treating a slope.

### Specifications

#### Spray range:

20 to 200 ft (6.1 to 61 m)  
360° horizontal rotation  
120° to 160° vertical travel

Tank capacity 150 to 3,000 gal (568 to 11,355 l)  
Pump capacity 70 to 950 gal per min (265 to 3,596 l/min)  
Power ratings 8 to 151 hp (6 to 113 kW)

### Availability

|  |   |
|--|---|
| Bowie Industries<br>Box 931<br>Bowie, Tex. 76230<br>(817) 872-2286 | Reinco<br>Box 584<br>Plainfield, N.J. 07061<br>(201) 755-0921 |
|--|---|

Finn Equipment Co.  
2525 Duck Creek Rd.  
Cincinnati, Ohio 45208  
(513) 871-2529

# Steep Slope Scarifier-Seeder

## Function

The steep slope scarifier-seeder, developed by the USDA Forest Service Equipment Development Center, San Dimas, California, establishes adequate and uniform plant cover on steep slopes at a reasonable cost. The implement is intended for road-cut and fill areas, but it may also be suitable for strip-mine reclamation sites.

## Description

The steep slope scarifier-seeder is mounted on a telescoping-boom crane to reach up and down the slope. The design incorporates individually spring-loaded scarifier tynes; two electrically powered rotary spreaders or seeders; a set of reversible spring tynes with dirt drags; and four wide, spring-loaded press wheels.

## Techniques

As the steep slope scarifier-seeder is maneuvered over the slope with the crane, the scarifier tynes break up and loosen the soil. Seed and fertilizer are then broadcast over the loose soil and covered with the dirt drags. The dirt drags may either be pressed down by the inverted tynes or, on hard packed soils, pulled behind the tynes. The soil is then firmed over the seed with the independently suspended press wheels. The steep slope scarifier-seeder has a production capability of 2 acres (.8 ha) per hour. Seeding rates can be varied from 5 to 60 lb per acre (5.8 to 67.5 kg/ha).

## Capabilities

The steep slope scarifier-seeder effectively plants seeds at a suitable depth on steep, easily eroded soils. The machine is maneuverable and is capable of planting over debris piles, stumps, rocks, and other obstacles. Debris can be left as a protective mulch for the seedlings. Because the seed is adequately covered and is not carried away by wind or water, uniform stands can be established on slopes of 45 to 75 degrees.

## Limitations

The steep slope scarifier-seeder cannot incorporate mulch. The implement can only be mounted on telescoping boom cranes, although a separate hitch is under development that would enable the steep slope scarifier-seeder to be towed behind other prime movers.



*Steep slope scarifier-seeder.*

## Specifications

Width 6 ft (1.8 m)  
Hopper capacity 2 cu ft (57 l)  
Weight 1700 lb (765 kg)  
Crane carriers - Warner and Swasey  
Gradalls or Drott-Cruz-Air

## Availability

Drawings are available from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (313) 332-6231  
FTS 793-8000

## Rotary Spreaders

### Function

Rotary spreaders broadcast seed, granular or pelletized herbicides, or fertilizers. They may be operated alone or in combination with various implements.

### Description

Rotary spreaders consist of hoppers that feed the material through an opening to one or two revolving fans, or spinners. One model has a rapidly moving pendulum device in place of a spinner. The rate of flow is determined by the size of the hopper opening. The material is distributed in a fan-shaped pattern that is adjustable for density and direction.

Most rotary spreaders are mounted on tractors or other vehicles. They are usually driven by power-take-off attachments or electric motors. Some rotary spreaders are hand operated. Large hoppers may have an agitator system to move the material to the spinners and to prevent the material from blocking the hopper opening.

### Techniques

Rotary spreaders are commonly used to broadcast seed during mechanical control operations. The action of the control implement produces an adequate seedbed or covers the seed.

Granular or pelletized herbicides are sometimes distributed with rotary spreaders. Complete coverage is possible in most types of terrain.

Rotary spreaders can also spread fertilizer over disturbed areas. Tillage implements, in combination with the rotary spreaders, work the material into the ground for increased effectiveness.

### Capabilities

Rotary spreaders are simple, reliable machines. They can be used easily in combination with other implements. Hand-operated models have no terrain limitations and are useful for spot treatments.

### Limitations

Rotary spreaders allow neither precise nor uniform distribution of materials. Broadcast materials are subject to movement by wind or water after application and seeds may be damaged during the broadcast operation. More efficient application methods are preferred where such treatments are possible.



*Hand-operated rotary spreader.*



*Rotary spreader.*



*Oscillating pendulum spreader.*

## Specifications

### Hand-Operated:

Pattern width 4 to 28 ft (1.2 to 8.5 m)  
Hopper capacity 350 to 925 cu in (5.7 to 15.1 l)  
to 40 lb (18 kg)

### Tractor or Vehicle-Mounted:

Pattern width 8 to 50 ft (2.4 to 15.2 m)  
Hopper capacity to 35 cu ft (991 l)  
to 2500 lb (1134 kg)

## Availability

### Hand-operated:

Cyclone Seeder Co., Inc.  
Box 68  
Urbana, Ind. 46990  
(219) 774-3339

Cyclone Seeder Co., Inc.

Box 68  
Urbana, Ind. 46990  
(219) 774-3339

Larson Machine, Inc.

Box 308  
Princeville, Ill. 61559  
(309) 385-4312

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Lely Southwest, Inc.  
Box 1026  
Temple, Tex. 76501  
(817) 938-2564

Hawk Bilt Co.  
402 East Sixth St.  
Vinton, Iowa 52349  
(319) 472-2313

Vandermolen Corp.  
119 Dorsa Ave.  
Livingston, N.J. 07039  
(201) 992-8506

### Tractor or vehicle-mounted:

AVCO  
EZEE Flow  
First and Sycamore St.  
Coldwater, Ohio 45828  
(419) 678-5396

Herd Seeder, Inc.  
Box 448  
Logansport, Ind. 46747  
(219) 753-6311

Vicon Farm Machinery, Inc.  
3741 Cook Blvd.  
Chesapeake, Va. 23323  
(804) 485-1600

Australian Farm Equipment  
1818 Westlake Ave. North  
Seattle, Wash. 98109  
(206) 284-9236

Horwood Bagshaw, Ltd.  
Box 270  
Clarence Gardens, South Australia 5039  
Australia

Wikomi Manufacturing Co.  
Box 100  
Litchfield, Ill. 62056  
(217) 324-5973

KMN-Modern Farm Equipment, Inc.  
12 Sullivan St.  
Westwood, N.J. 07675  
(201) 666-3707

## Grass Seeder

### Function

The grass seeder produces dense, uniform stands of grass on well-prepared seedbeds. It has successfully seeded strip-mine reclamation areas, farmland, and pastures.

### Description

The grass seeder has a seed box spreader mounted between two standard cultipackers. The spreader has two hoppers. The cultipackers have closely spaced, V-shaped grooves, about 1-in (2.5 cm) deep. The grooves of the two cultipackers are offset to cover the broadcast seed. The grass seeder is available in both pull-type and three-point mounted models.

### Techniques

The first cultipacker smooths and firms the seedbed while creating several small furrows. The seed is broadcast onto the ground from the seed box spreader and falls into the furrows. The second offset cultipacker fills in the original furrows and creates new ones between the rows of seed.

### Capabilities

The seed is planted at the proper depth on a firm smooth seedbed. The miniature furrows created by the

second cultipacker firm the soil around the seed and help direct infiltration. The closely spaced rows produce a uniform stand when the plants mature. The two hoppers can broadcast two types of seed or both seed and fertilizer in one pass.

### Limitations

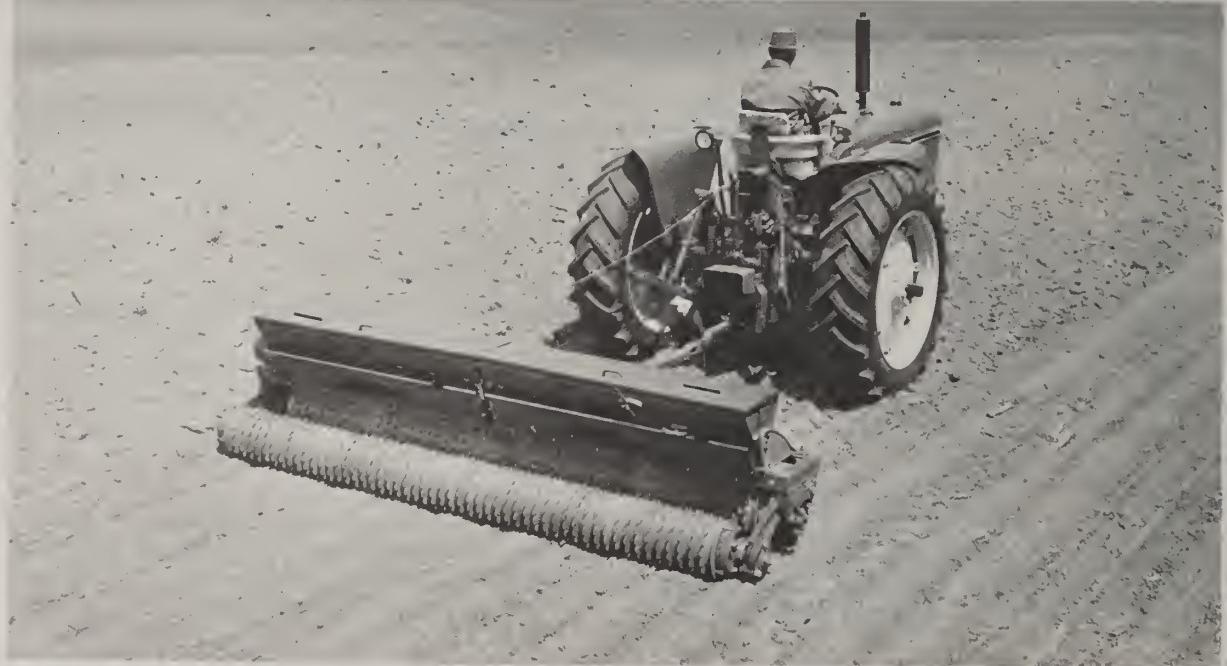
The grass seeder requires thorough seedbed preparation. It is not suited to rough, rocky, or brushy areas. The small furrows wear down quickly during severe weather.

### Specifications

Width 5 to 12 ft (1.5 to 3.7 m)  
Roller diameter 12 in (30 cm) front  
9 in (23 cm) rear  
Hopper capacity .9 to 6.5 cu ft (26 to 185 l) front  
1.6 to 6.5 cu ft (44 to 185 l) rear  
Power requirements (drawbar) 40.h.p (30 kW)

### Availability

Brillion Iron Works  
200 Park Ave.  
Brillion, Wis. 54110  
(414) 756-2121



Grass seeder.

# Grain Drills

## Function

Grain drills plant grain or grass on well prepared seedbeds. Granular or pelletized fertilizer is often applied along with the seed.

## Description

Grain drills consist of furrow openers, seed metering devices, hoppers, and seed covering devices. The furrow openers may be chisel shanks, single disks, or double disks. Depth regulating bands are often attached to the disks to precisely control seeding depth. Chisel shanks are useful in dry soils, single disks can cut and chop through trash, and double disks permit the most accurate seed placement. Fluted seed-metering devices generally control the flow of seed from the hopper to the furrow openers. They are driven by the drill wheels and have gear arrangements that are easily adjusted to control the seeding rate. The hoppers most often have two compartments allowing both seed and fertilizer to be applied. Separate hoppers for small grass seed are available. Agitators in the hoppers prevent blocked openings. Baffles insure even distribution on steep slopes. Press-wheels or drag devices cover the seed and close the furrows. Grain drills may be supported by side-wheels or with the press-wheels. They are usually towed, but may be mounted on a three-point hitch. Most grain drills are equipped with hydraulic lifts.

## Techniques

Grain drills open a small furrow in the seedbed, deposit the seed in the furrow, and close the furrow, covering the seed. Fertilizer can also be placed with the seed. Press-wheel drills support the weight of the drill on the press wheels that pack the soil into close contact with the seed to aid germination, and create small furrows that protect the seedlings. Side-wheel drills cover the furrows without packing the soil over the seed. However, they are better adapted to rough ground and uneven terrain.

## Capabilities

Grain drills are perfectly suited for seeding smooth, well-prepared seedbeds that are free from rocks and brush. Models are available with various row spacings, furrow openers, seeding rate controls, and other features for a variety of seeding needs.

## Limitations

Grain drills are not well suited to rocky ground, rough terrain, or areas with many brush snags. Slow operating speeds and careful maintenance are necessary for grain drills to withstand the rigors of rangeland use.



*Side-wheel grain drill.*



*Presswheel drill with double-disk openers.*

## Specifications

Width 6 ft 8 in to 26 ft 8 in (2 to 8.1 m)

Row spacing 6 to 18 in (15 to 46 cm)

Hopper capacity 13 to 56 cu ft (350 to 1,570 l)

Power requirements (drawbar):

20 to 25 hp (15 kW) single

30 hp (22 kW) dual or triple

## Availability

Grain drills are available from many farm implement manufacturers and farm equipment dealers

## Pasture Drills

### Function

Pasture drills are heavy-duty grain drills adopted for seeding grass in stubble or pastures without prior seedbed preparation. Some pasture drills may also treat rangeland.

### Description

Pasture drills are built on heavy-duty frames to better withstand the rigors of grassland seeding. Most pasture drills feature double-disk openers and large seed tubes for precise placement of grass seed, although some designs have flexing runner or chisel openers. Some drills are equipped with single-disk coulters in front of the openers or heavy-duty press wheels in back. They often have hydraulic or spring-loaded mechanisms to supply additional down pressure to the coulters or openers. The hoppers are similar to conventional grain drills and may have baffles to insure uniform seed distribution. Fertilizer hoppers are also available. Various agitator and feed mechanisms have been adapted for fluffy or chaffy grass seed. Pasture drills may be towed, or mounted on a three-point hitch.

### Techniques

Pasture drills sow grass or grain seed directly into stubble, pasture, or grassland. They are designed for minimum tillage. The coulters or openers penetrate the surface trash or mulch and place the seed into the underlying soil. Depth bands are available to regulate seeding depth. Press-wheels firm the soil over the seed. Seeding rates are adjustable.

### Capabilities

Pasture drills are specially designed for grass seed. Many of them drill fluffy or chaffy seed effectively. Pasture drills are more sturdily constructed than most grain drills.

### Limitations

Competition for moisture and soil nutrients may be too severe for seedlings to become established without previous seedbed preparation. Most pasture drills are not suited to rough, rocky, or brushy areas.



*Grass drill with chisel openers.*



Pasture drill with double-disk openers and coulter disks.



Range drill with flexible runners.

## Specifications

### Drills with double-disk openers:

Overall width 6 ft 8 in to 16 ft 4 in (2 to 5 m)  
Working width 6 ft to 13 ft 2 in (1.8 to 4 m)  
Row spacing 6 to 8 in (15 to 20 cm)  
Hopper capacity 13 to 45 cu ft (350 to 1270 l)  
Power requirements (drawbar):

30 hp (22 kW) single  
45 hp (34 kW) dual

### Drills with flexing runner or chisel type openers:

Overall width 6 ft 8 in to 23 ft 8 in (2 to 7.2 m)  
Working width 6 ft to 19 ft 5 in (1.8 to 5.9 m)  
Row spacing 7 in (18 cm)  
Hopper capacity 13 to 32 cu ft (350 to 900 l)  
Power requirements (drawbar):

30 hp (22 kW) single  
45 hp (34 kW) dual

## Availability

### Drills with double-disk openers:

P & D Duncan, Ltd.  
Box 124  
Christchurch, New Zealand

Haybuster Manufacturing Co.  
Box 1008  
Jamestown, N.Dak. 58401  
(701) 752-4601

Melroe Division Ag. Products  
Clark Equipment Co.  
Box 1215  
Bismarck, N. Dak. 58501  
(701) 222-5000

Midland Manufacturing Co.  
Electric Mills, Miss. 39320  
(601) 476-3061

Miller Seed Co.  
Box 81823  
Lincoln, Nebr. 68501  
(402) 432-1232

Truax Co.

3717 Vera Cruz Ave.  
Minneapolis, Minn. 55422  
(612) 537-6639

The Tye Co.

Box 218  
Lockney, Tex. 79241  
(806) 852-3597

Drills with flexing runner or  
chisel type openers:

Aitchison Industries, Ltd.  
Box 27  
Wanganui, New Zealand

Australian Farm Equipment Pty., Ltd.  
1818 Westlake Ave. North  
Seattle, Wash. 98109  
(206) 284-9236

Horwood Bagshaw, Ltd.  
Box 270  
Clarence Gardens, South Australia, 5039  
Australia

Napier Grasslands Pty., Ltd.

Box 244  
Taree, NSW, 2430  
Australia

The Tye Co.

Box 218  
Lockney, Tex. 79241  
(806) 852-3597

Information may be obtained  
from:

Texas Agricultural  
Experiment Station  
Texas A&M University  
Box 1658  
Vernon, Tex. 76384  
(817) 552-9941

## Rangeland Drill

### Function

The rangeland drill was designed for treating rangeland by the USDA Forest Service Equipment Development Center at San Dimas, California. It is a rugged, versatile implement for drilling in rough, rocky, or brushy areas.

### Description

The rangeland drill is a very heavy-duty, side-wheel drill. It features large wheels, a high-clearance reinforced frame, and single-disk openers that are independently suspended on trailing arms. The trailing arms have skid plates underneath to prevent breakage. Heavier deep furrowing arms are also available. The furrows are covered with drag chains or 2-in (5 cm) diameter pipe drags, 42 to 48 in (107 to 122 cm) long. The 20-in (51 cm) disk openers can be equipped with 14-in (36 cm), 16-in (41 cm), or 18-in (46 cm) depth control bands.

The drill can be equipped for deep furrow drilling with special deep furrowing arms and heavy-duty 24-in (61 cm) disks. The disk angles can be adjusted on deep furrowing arms to better control small brush and competing annuals in the furrows. Other available options include: a small-seed hopper attachment, a fertilizer attachment, a brush guard to protect the running gear, and steel wheels for areas with numerous brush snags where rubber tires cannot operate. The drill can be modified for reduced seeding rates and large scale chemical applications. Half size, or 5-ft (1.5 m) models are also available.

### Techniques

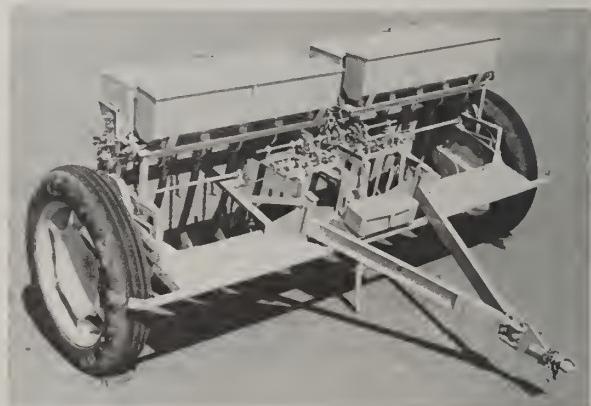
The rangeland drill can be operated on areas with or without previous seedbed preparation, however heavy brush stems should be removed to reduce damage and delays. Production rates average 2.5 to 5.0 acres (1 to 2 ha) per hour for rubber side wheels and about half that rate for steel wheels. Furrow depth can be controlled with the depth bands or by adding weights to the trailing arms. Pipe drags are attached during deep furrow drilling operations to pack the soil in the furrows. The furrows provide shelter and increased moisture for the seed and seedlings. The rangeland drill has the capacity to seed two species and apply fertilizer at the same time.

### Capabilities

The rangeland drill is adapted to seeding rough, rocky terrain. It has the capacity to control small brush or annuals. It is often used in areas that have been burned or chemically treated. The rangeland drill can plant a variety of seeds at widely varying rates. Seeding depth is easily controlled and the furrows control erosion and aid seedling establishment.

### Limitations

The row spacing may be too wide for some applications. Excessive breakage and down time will result if the drill is operated in areas with heavy brush or trash. The drilling operation becomes more efficient with better seedbed preparation. Slopes too steep for contour operation should not be drilled. The rangeland drill is difficult to transport without special equipment and techniques.



*Rangeland drill capable of metering fluffy or trashy seed.*

### Specifications

#### Overall width:

8 ft 6 in (2.6 m) half size

13 ft 6 in (4.1 m) full size

#### Working width:

5 ft (1.5 m) half size

10 ft (3 m) full size

Row spacing 12 or 18 in (30 to 46 cm)

Hopper capacity 13 to 36 cu ft (460 to 1,030 l)

#### Power requirements (drawbar):

40 hp (30 kW) minimum

45 hp (34 kW) recommended

65 hp (48 kW) dual

90 hp (67 kW) triple

### Availability

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 268-8128

Drawings (RM27-01-61), Service & Parts Manual, & Operations Handbook available from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

## Oregon Press Seeder

### Function

The Oregon press seeder seeds grasses in light, loose soils. It was developed for soils associated with big sagebrush (*Artemesia tridentata*) in Oregon. It places seed in a firm seedbed and covers it with loose soil.

### Description

The Oregon press seeder consists of 12 heavy steel press-wheels, 32 in (81 cm) in diameter with a 6-in (15 cm) tread. Each wheel is independently suspended. A 1-in (2.5 cm) V-shaped ridge in the center of the tread creates furrows for the grass seed. Seed metering devices and a hopper from a standard grain drill are mounted on top of the heavy-duty frame. Coil spring seed tubes place the seed in furrows and conventional drag links close the furrows and cover the seed.

### Techniques

The press-wheels support the weight of the seeder and pack the loose soil into a firm seedbed. The seed is placed in the groove at the center of the tread and covered with loose soil. The packed soil underneath the loose soil covering forms an excellent seedbed. Moisture is made available for root growth in the packed soil, while leaf growth remains unobstructed by the loose covering. Ditches should be crossed at an angle to prevent damage to the seed tubes.

### Capabilities

The Oregon press seeder is useful in dry, loose soils commonly found in sagebrush-bunch grass areas. The

independent suspension allows the seeder to follow terrain fluctuations and operate over rocks and brush.

### Limitations

The Oregon press seeder is not designed for heavy, compacted soils or as a deep furrow drill. The rangeland drill has proved more trouble-free in rough terrain. Use of the Oregon press seeder has diminished in recent years.

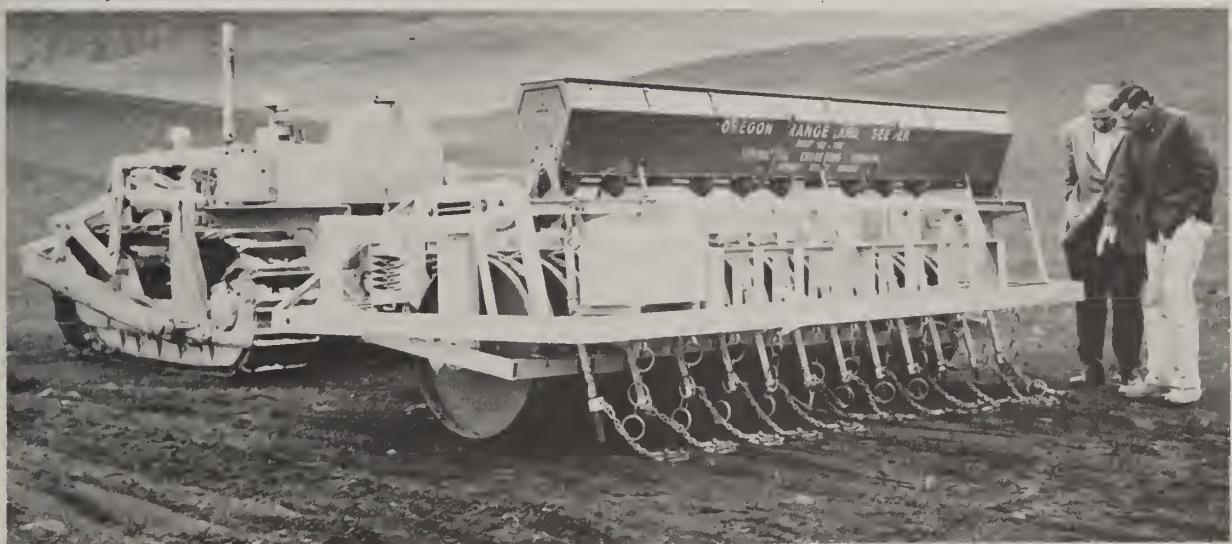
### Specifications

Width 13 ft (4 m)  
Furrow spacing 12 in (30 cm)  
Hopper capacity 31 to 43 cu ft (850 to 1,200 l)  
Power requirements (flywheel) 42 to 72 hp (31 to 54 kW)

### Availability

Drawings (RM19-01 to 07) and information can be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000



Oregon presswheel drill.

# Powr-Till Seeder

## Function

The Powr-till seeder is a power interseeder to increase production or add new species to established stands without seedbed preparation.

## Description

The Powr-till seeder is a side-wheel grain drill with pto-powered, single-disk furrow openers. The 12-in (30 cm) diameter, toothed-disks rotate in the direction of travel. Seed is placed in the narrow furrows by steel boots that fit over the rubber seed tubes. Fertilizer can be applied along with the seed. Loose soil is packed over the seed with narrow, 10-in (25 cm) diameter press-wheels. Spray nozzles can be placed on the front of the Powr-till seeder to apply a 4-in (10 cm) swath of contact herbicide over each row.

## Techniques

Narrow furrows from  $\frac{3}{4}$ - to 1-in (1.9 to 2.5 cm) deep are formed in the soil or sod. The action of the powered disk throws the soil backward and some of the loose soil falls onto the seed placed in the furrow. Narrow press-wheels follow in the furrow, packing the soil over the seed. Contact herbicide is sprayed over the furrows to control competing vegetation and fertilizer can be added to aid seedling establishment.

## Capabilities

The Powr-till seeder is adapted to seeding pastures or grassland without prior seedbed treatment. New species can be added to existing stands to improve forage quality and quantity. The new seedlings are established quickly allowing grazing to be resumed within several weeks.

## Limitations

The Powr-till seeder is limited to fairly rock free, level ground. Seeding failures may result if excessive plant competition is not controlled or if livestock are not removed during seedling establishment.



*Powr-till seeder.*

## Specifications

Overall width 10 ft (3 m)  
Working width 8 ft (2.4 m)  
Furrow spacing 8 in (20 cm)  
Hopper capacity 3.1 to 15.6 cu ft (87 to 442 l)  
Power requirements (drawbar) 60 to 80 hp  
(45 to 60 kW)

## Availability

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

## Standard Unit Planters

### Function

Standard unit planters plant row crops at precise intervals on well-prepared seedbeds. They may plant shrub or tree seeds on rangeland or disturbed land reclamation sites.

### Description

Standard unit planters are self contained, separate planting units mounted on a toolbar. Each planter consists of an opener, a seed metering device, a hopper, a furrow covering device, and a press-wheel. Various openers include single disks, double disks, chisel shanks, moldboards, or listers (double moldboards). The seed metering devices can be easily adjusted over a wide range of seeding rates. They may be notched horizontal plates, channelled vertical plates, air-powered disks, or air-powered drums. Hoppers, for seed and up to three chemicals, can be mounted on each planter. Disks, shovels, blades, or drag chains close the furrows. Press-wheels firm the soil over the seed and usually supply the drive to operate the planters.

### Techniques

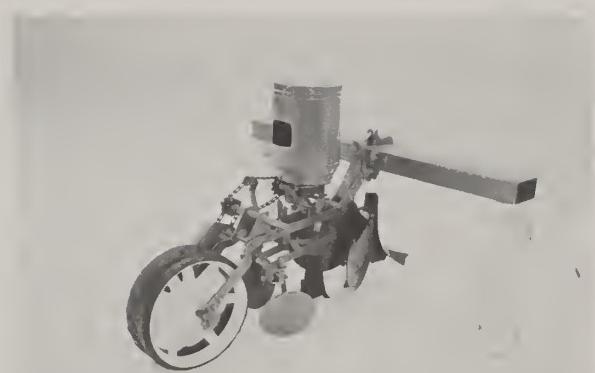
Standard unit planters are mounted on a toolbar that may be raised and lowered hydraulically. The tractor moves over the area and seeds are sown at regular intervals. The planters are independently suspended to follow varying terrain.

### Capabilities

Standard unit planters were developed for precise placement of seed. Seed spacing and depth can be controlled with various adjustments. Granular fertilizers, herbicides, or insecticides can also be applied at the time of seeding.

### Limitations

Standard unit planters are adapted to well-prepared seedbeds and are not suited to rough, rocky, or brushy areas. They should only be used where precise spacing of seed is desired. The small hoppers may require frequent filling.



Standard unit planter on a toolbar.



Air-powered planter units on a frame.

### Specifications

Width to 28 ft 4 in (8.6 m)  
Seed spacing  $\frac{3}{4}$  to 35 in (2.89 cm)  
Row spacing 11 to 40 in (28 to 102 cm)  
Hopper capacity to 1.6 cu ft (45 l)  
Power requirements (drawbar) 20 hp  
(15 kW) minimum

### Availability

Standard unit planters are available from many farm implement manufacturers and farm equipment dealers.

## Range Interseeder

### Function

The range interseeder is designed to improve existing stands of vegetation in areas where complete seedbed preparation is impractical or undesirable. Range interseeders can operate on the contour to increase moisture availability and prevent erosion.

### Description

Range interseeders are heavy-duty unit planters with listers or scrapers for furrow openers. Grass, forbs, or browse can be seeded at various rates. Hoppers for both large and small seeds are attached. A press-wheel packs soil over the seed and provides the traction to operate the metering devices. Depth regulating wheels are mounted in front of the furrow openers. Two or three units are usually mounted on a toolbar.



*Range interseeder with large scrapers.*

### Techniques

Wide, shallow furrows are created in the ground or sod, and seed is planted in the centers of the furrows. The wide furrows eliminate competitive vegetation and provide shelter and increased moisture for establishing seedlings. The vegetation left between the furrows prevents erosion and shades the furrows. Check dams can be created by briefly lifting the range interseeders from the soil while moving along the contour.

### Capabilities

Range interseeders can seed grass, forbs, or shrubs in areas without previous seedbed preparation. They increase forage quantity and quality within a few years without eliminating the original vegetation. Range interseeders are most often operated in sandy soils but may be used in silty soils.

### Limitations

Competition for moisture may limit the establishment and maintenance of interseeded plants on very dry sites. Livestock must be carefully managed on interseeded areas to prevent overgrazing. Range interseeders may be difficult to operate on clay soils because of soil crusting and sticking. They are not well-suited to steep, rough, or rocky areas.

### Specifications

Furrow width 8 to 32 in (20 to 81 cm)  
Furrow depth 1.5 to 4.7 in (3.8 to 12 cm)  
Row spacing 3 to 6.5 ft (.9 to 2 m)  
Hopper capacity to 1.6 cu ft (45 l)  
Power requirements 20 hp (14 kW) minimum

### Availability

Miller Seed Co.  
Box 81823  
Lincoln, Nebr. 68501  
(402) 432-1232

R. A. Whitfield Manufacturing Co.  
6431 Gordon Circle SW  
Mableton, Ga. 30059  
(404) 948-1212

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

## Interseeder for Rocky and Brushy Areas

### Function

The interseeder for rocky and brushy areas was designed specially for rough rangeland conditions by the USDA Forest Service Equipment Development Center at San Dimas. It can create deep, wide furrows; seed a wide variety of plants; and operate effectively on rocky and brushy ground.

### Description

The interseeder for rocky and brushy ground consists of a small crawler-tractor, a ground working tool or implement, a thimble-seeder seed dribbler, a pneumatic seed transfer system, and a chain drag. Ground working tools or implements have included fireplows, double-disk (Holt) trenchers and Rocky Mountain single-disk trenchers. Fireplows are by far the most effective. The tractor, a John Deere 350, is equipped with a three-way dozer and an implement-carrying hitch that allows the ground working tool or implement to remain in the ground as the tractor pitches over rough terrain. A gage wheel controls the furrow depth when using disk trenchers. The seed dribbler eliminates problems that would be encountered with ground-operated seeders.

The pneumatic seed transfer system consists of a turbo charger, a venturitube, a plastic tube leading to the trencher, a cyclone separator, and a tube that deposits the seed behind the working tool or implement. The turbo charger is an exhaust-powered device that provides the airflow necessary to move the metered seed back to the trencher. The cyclone separator removes the seed from the airstream and funnels it into the gravity feed tube, which deposits the seed in the furrow. A loop of heavy chain attached to the trencher provides adequate seed coverage.

### Techniques

The trenchers create furrows deep enough to remove the roots and rhizomes of competitive plants and wide enough to prevent reinvasion until the seeded plants are well established. Fireplows create very wide furrows necessary for interseeding certain areas. The furrows also intercept and store moisture. The seed dribbler meters the desired amount of seed and the pneumatic transfer system deposits the seed in the furrows. The drag chain immediately covers the seed to prevent loss and enhance germination and growth.



*Interseeder for rocky and brushy land.*

## **Capabilities**

The interseeder for rocky and brushy areas can plant smooth, fluffy, or trashy seed on rough, rocky ground. The furrows control competing vegetation, increase moisture availability, and, for the most part, reduce reinvasion until the plants can be established.

## **Limitations**

Contours should be followed closely on steep terrain to reduce the erosion hazard. Grazing should be controlled on interseeded areas to insure successful plant establishment.

### **Specifications**

Width 14 to 36 in (36 to 91 cm)  
Depth to 8 in (20 cm)  
Hopper capacity 925 cu in (15 l)  
Power ratings 42 hp (31 kW)

### **Availability**

Drawings and information can be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

The equipment in this section is for planting or transplanting trees and shrubs. Planting or transplanting is often preferred to seeding because older trees and shrubs are established that are more likely to survive and reproduce. More mature plants are less subject to environmental stresses like drought, extreme temperatures, strong winds, and snow loading that may limit seed germination and seedling growth.

Planting reduces the uncertainty of obtaining a suitable stand from seed. Seedlings are grown under controlled conditions in a nursery or greenhouse to assure maximum growth and survival. Planting uses available seed more efficiently by eliminating problems with seed viability, seed destruction, or improper seed placement. However, planting is costly and time consuming. It should be restricted to only the most favorable sites.

Transplanting trees or shrubs from adjacent sites quickly establishes mature plants on disturbed areas. In addition, native stock is well-adapted to the site. A transplanting operation should include careful selection of vigorous transplant stock, careful removal to reduce root damage, accurate placement to avoid sunscald, judicious pruning to reduce transpiration, and adequate support to prevent windthrow. Generous amounts of water and fertilizer should be provided to insure rapid root growth and aid survival. Although such intensive transplant care may not be practical, field personnel should take appropriate precautions to avoid damaging the transplants needlessly.

## Seedling Planters

### Function

Seedling planters are tractor-drawn implements that open furrows for bare root tree or shrub seedlings and pack the soil around the seedlings after they are placed. An operator sits in the planter to place the seedlings in the furrows at selected intervals.

### Description

Seedling planters may be towed or mounted on a tractor or four-wheel drive vehicle. They consist of a single disk coulter, a furrow opener, a set of two packing wheels, a seat for the operator, and a place to store the seedlings. Some planters are semi-automatic and feature mechanical arms that place the seedlings.

The heavy frame is supported by the rear packing wheels. The disk coulter cuts into the ground and the furrow opener expands the furrow to accept the seedling. The packing wheels are angled inward to insure that the furrow is completely closed and that the soil adequately contacts the seedling roots.

An enclosure may be provided for the comfort and protection of the operator. Most seedling planters are equipped with signal devices to alert the tractor or vehicle driver if necessary. Seat belts are also provided for safety.

### Techniques

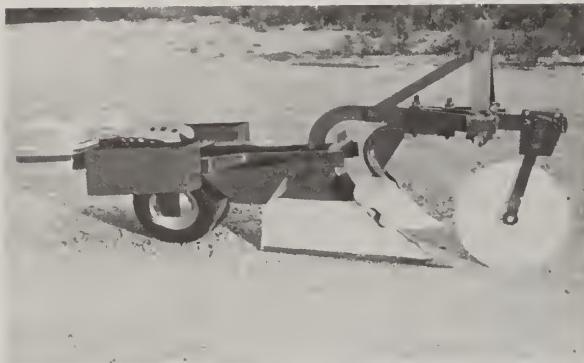
As the seedling planters are pulled over the area, the operator places the seedlings directly in the furrow or into the placement arms on semi-automatic planters. Various devices provide even spacing, or the seedlings can be planted at irregular intervals. Planting rates commonly average from 1,000 to 1,500 seedlings per hour.

### Capabilities

Seedling planters can quickly and consistently plant large numbers of seedlings. They contribute to increased survival because deep root penetration and adequate soil compaction are assured. Seedling planters are generally simple, reliable machines.

### Limitations

Seedling planters may be limited by site or terrain conditions. They are not suited to slopes over 20 percent and cannot operate over large obstructions such as stumps, logs, or large rocks. The seedlings are planted linearly and the furrows may contribute to erosion or frost heaving. Bare root stock may not be able to absorb enough moisture, particularly on arid sites, because most of the fibrous roots are destroyed during the transplant process.



*Typical seedling planter.*



*Forestland tree planter.*

### Specifications

Furrow width 2.8 to 3.5 in (7 to 8.9 cm)  
Furrow depth to 14 in (36 cm)  
Disk diameter to 30 in (76 cm)  
Weight 1,650 to 4,300 lb (748 to 1,950 kg)  
Power requirements (drawbar) 60 hp (45 kW)  
minimum

### Availability

Cazes and Heppner Forest Services, Ltd.  
2450 Rideau Circle  
Abbotsford, B.C., Canada V2T 3N4  
(604) 853-0674

Grayco Potato Harvesters, Ltd.  
Heidleburg, Ont., Canada N0B 1Y0  
(519) 699-5372

Groundbreakers, Inc.  
Box 321  
Plainfield, Ill. 60544  
(815) 436-7463

Hakmet, Ltd.  
179 Place Frontenac  
Pointe Claire, Quebec, Canada H9R 4Z7  
(514) 694-4791

Jackson Manufacturing and Welding Co.  
Box 217  
Lebanon, Tenn. 37087  
(615) 444-0871

Noecker's Tree Farms  
Rural Route 6, Box 312  
Allegan, Mich. 49010  
(616) 673-6215

Pettibone Michigan Corp.  
Box 368  
Baraga, Mich. 49908  
(906) 353-6611

Reynolds Research and Manufacturing Corp.  
Box 550  
McAllen, Tex. 78501  
(512) 686-0208

Taylor Machine Works, Inc.  
Box 150  
Louisville, Miss. 39339  
(601) 773-3421

Utility Tool and Body Co.  
Box 360  
Clintonville, Wis. 54929  
(715) 823-3167

R. A. Whitfield Manufacturing Co.  
6431 Gordon Circle, SW  
Mableton, Ga. 30059  
(404) 948-1212

# Steep-Slope Containerized Planter

## Function

The steep-slope containerized planter was developed by the USDA Forest Service Equipment Development Center at San Dimas, California, to plant containerized stock on road cut and fill areas. It may be adapted to some reclamation sites as well.

## Description

The steep-slope containerized planter is crane-mounted and contains two separate planters that operate simultaneously. The planters each consist of a retractable auger, a carousel that contains the seedlings, a telescoping seedling drop tube, and a packing spade. All components are hydraulically operated.

## Techniques

The entire planting procedure is automatic. The crane operator positions the steep-slope containerized planter and flips the start switch. The auger drills a hole in the ground. Separate switches allow the operator to stop each planter independently if one auger cannot penetrate. When the auger is retracted, the carousel rotates to position the seedling. The seedling is then forced through a telescoping tube into the hole with a jet of water. When the seedling tube returns to the original position, the packing spade firms the soil around the seedling.

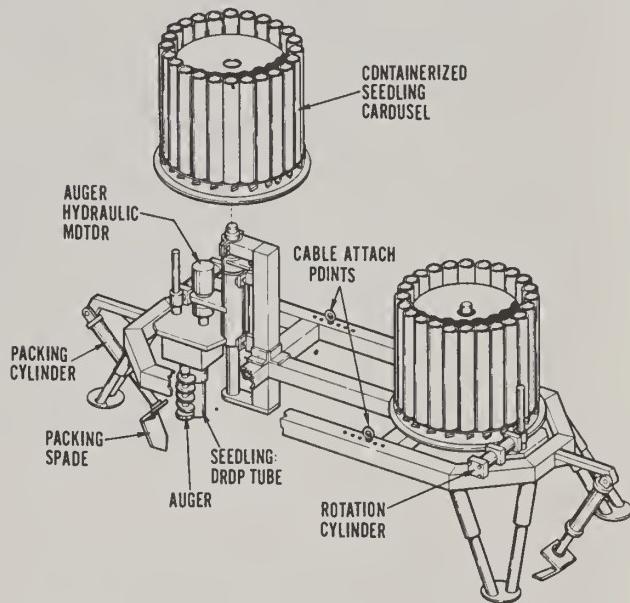
The carousels can be easily removed for reloading. The planting rate is estimated at two plants per minute.

## Capabilities

The steep-slope containerized planter can plant shrubs and trees on 60 to 100 percent slopes. The augers drill deep holes to help insure adequate moisture availability and root growth. Containerized seedlings generally exhibit good survival and growth because the fibrous roots remain intact. The steep-slope containerized planter enables rapid revegetation of denuded slopes.

## Limitations

The steep-slope containerized planter must be operated with a crane. The planter requires containerized stock. Seedling survival may be affected by several environmental factors after planting.



*Steep-slope containerized planter.*

## Specifications

Carousel capacity 24 seedlings  
Auger diameter 3 in (7.6 cm)  
Depth 9 in (23 cm)  
Weight 1,200 lb (544 kg)  
Crane carriers. The steep-slope containerized planter can be attached to any crane capable of supporting the weight.

## Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

## Tree Spades

### Function

Tree spades are designed to dig and transplant trees and shrubs with a minimum of root damage. The trees and shrubs are transported in a ball of soil that remains undisturbed and keeps the roots intact.

### Description

Tree spades are available in three- or four-blade designs. They are available with or without solid digging platforms. The digging platforms allow precise positioning of the tree spade around the tree and usually have leveling devices. The tree spade blades are lowered into the ground hydraulically to form a semi-spherical or cone-shaped soil ball. Tree spades can be mounted on trucks, tractors, trailers, or front-end loaders. Larger tree spades usually have water tanks to lubricate the blades.

### Techniques

The tree spade is positioned around the tree and the blades are lowered. The roots are cleanly severed, leaving many of them intact within the soil ball. The tree can either be transported in the tree spade or loaded on a truck or trailer.

Digging platforms allow precise placement of the tree within the soil ball. The leveling devices insure that the tree is placed upright at the transplant site. They also enable the entire platform to be raised when digging the tree, creating a catch basin when the smaller soil ball is placed in the larger transplant hole.

### Capabilities

Tree spades are efficient transplanting machines. They transplant trees and shrubs with a minimum of root damage and soil disturbance. The cone-shaped, four-blade configurations allow deeper penetration, but the three-blade models can generally operate faster.

### Limitations

Tree spade operation is limited to slopes of 15 percent or less. If the slope is greater than 15 percent, the difference between the uphill and downhill side of the tree may result in a soil ball that is too shallow to avoid severing many large roots during the digging process. Tree species with large taproots are also difficult to transplant successfully because much of the root system may be cut off when the tree is removed.

Tree spade operation becomes uneconomical as transport distances approach 1 mile (1.6 km) or as transport times exceed 1 hour.



*Three-blade tree spade on a skid-steer loader.*



*Three-blade tree spade with open digging platform.*



*Large tree spade mounted on a truck.*



*Trailer-mounted four-blade tree spade.*

## Specifications

### Three blade:

Ball (cone) diameter 30 in (76 cm)  
Ball (cone) depth 16 in (41 cm)  
Tree size\* to 3 in (8 cm) diameter  
Mounting - rear-wheel drive tractors or small front-end loaders.

### Four blade:

Ball (cone) diameter 20 to 78 in (51 to 198 cm)  
Ball (cone) depth 18 to 60 in (46 to 152 cm)  
Tree size\* to 10 in (25 cm) diameter  
Mounting - tractors, trailers, truck or front-end loaders

\*Maximum tree size may vary with the type of root structure.

## Availability

### Three blade:

Arrowhead Creative Products  
6340 Rice Lake Rd.  
Duluth, Minn. 55803  
(218) 724-1945

Caretree Systems  
Box 347  
Worthington, Ohio 43229  
(614) 846-2665

Melroe Div.  
Clark Equipment Co.  
112 North University Dr.  
Fargo, N.Dak. 58102  
(701) 293-3220

### Four blade:

Big John Tree Transplanter Mfg. Co., Inc.  
Box 608  
Heber Springs, Ark. 72543  
(501) 362-8161

Vermeer Manufacturing Co.  
Box 200  
Pella, Iowa 50219  
(515) 628-3141

# Tree Transport Trailer

## Function

The tree transport trailer was designed by the USDA Forest Service, Equipment Development Center at Missoula, Montana, to haul eight transplants at one time. It is intended for use with a four-blade tree spade mounted on an articulated front-end loader.

## Description

The tree transport trailer consists of two rows of four cone-shaped pods. The pods are 44 in (112 cm) in diameter and 40 in (108 cm) deep. A hatch is located at the bottom of each pod to aid cleaning. Two hold-down plates are attached to each rim to secure the soil plugs during transport.

Each row of pods can be tilted backward with a winch to facilitate transport. The trailer has removable outer walkways, tandem axles, electric brakes, and lights for highway travel. The eight-tree size was chosen for optimum capacity and maneuverability.

## Techniques

Eight soil plugs are removed from the transplant site, loaded into the trailer, and transported to the transplant supply area. They are then replaced in the trailer with selected trees and shrubs that are transported back to the transplant site and planted. The front-end loader-mounted tree spade digs the trees or plugs, places them in the trailer pods, and tows the trailer between the transplant site and transplant supply area.

## Capabilities

The tree transport trailer greatly reduces the transport time required for each tree. Up to 24 trees per day can be transplanted with the tree transport trailer system. The front-end loader-mounted tree spade is very maneuverable and can negotiate slopes up to 20 percent.

## Limitations

The tree transport trailer requires a front-end loader-mounted tree spade to provide the clearance needed to load the trees. The system is expensive, but makes tree spades more feasible over greater distances.

## Specifications

Overall width 8 ft (2.4 m) with walkway removed  
Height 7 ft (2.1 m)  
Weight 6,000 lb (2,722 kg)  
Capacity 8 trees or plugs or 8,800 lb (3,992 kg)  
Cone size 44 in (112 cm) diameter  
40 in (108 cm) deep  
Power requirements 80 hp (60 kW) recommended

## Availability

Drawing (No. 602) and information can be obtained from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157



*Tree transport trailer towed by a small front-end loader equipped with a tree spade.*

# Front-End Loaders

## Function

Front-end loaders are for digging, loading, and hauling overburden or coal in strip mines. They also remove topsoil and transplant shrubs and trees. Small loaders accomplish a variety of materials-handling jobs.

## Description

Front-end loaders are four-wheel, rubber-tired loading machines with a large bucket on the front. Most front-end loaders have single engines, all-wheel drive, and hydraulically controlled buckets. They are available in a wide range of sizes. Most loaders feature articulated steering, but some very small loaders are skid-steer types. Separate loader buckets are available that mount on conventional farm tractors. Crawler loaders and industrial wheel loaders are also available.

## Techniques

Loose material is scooped up in the bucket and either loaded into trucks or dumped in another location. Transplanting is accomplished by carefully lifting individuals, or by scraping up a series of root pads, and placing the transplants on previously prepared sites.

## Capabilities

Front-end loaders are versatile, mobile machines. They are readily available at most strip mine sites and can be obtained easily for reclamation work. Skid-steer loaders are very maneuverable and can turn completely around within their own length. They are well suited to most materials-handling tasks.

## Limitations

Front-end loaders are limited to slopes of under 20 percent because suspension characteristics make them unstable on steeper slopes. Hauling with front-end loaders is uneconomical except for short distances. Transplanting with front-end loaders may result in considerable root damage and loosening of the soil around the plant.



*Typical skid-steer loader.*



*Large articulated front-end loader commonly available at mine sites.*

## Specifications

### Articulated front-end loaders:

Bucket capacity to 24 cu yds (18 kl)  
to 36 tons (32.7 metric tons)

Width to 20 ft (6.1 m)

### Power ratings (flywheel):

to 690 hp (515 kW) single engine  
2 x 635 hp (2 x 474 kW) dual engines

### Skid-steer loaders:

Bucket capacity 5 to 57 cu ft (142 to 1,614 l)

500 to 3,700 lb (227 to 1,678 kg)

Width 35 to 84 in (89 to 213 cm)

Power ratings 16 to 72 hp (12 to 55 kW)

## Availability

### Articulated front-end loaders:

Allis Chalmers  
Agricultural Equipment Div.  
Box 512  
Milwaukee, Wis. 53201  
(414) 475-2965

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6011

Caterpillar Tractor Co.  
100 Northeast Adams  
Peoria, Ill. 61629  
(309) 675-1000

Clark Construction Machinery Div.  
Clark Equipment Co.  
Box 547  
Benton Harbor, Mich. 47022  
(616) 927-7200

Dart Truck Co.  
Box 321  
Kansas City, Mo. 64141  
(816) 483-7679

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Eaton Yale, Ltd.  
Forestry and Construction Equipment Div.  
Box 160  
Woodstock, Ontario, Canada N4S 7X1  
(519) 537-6271

Fiat-Allis Construction Machinery, Inc.  
106 Wilmont Rd.  
Deerfield, Ill. 60015  
(312) 948-5000

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 643-2000

International Harvester  
Payline Group  
600 Woodfield  
Schaumburg, Ill. 60196  
(312) 948-5500

Marathon LeTourneau Co.  
Longview Div.  
Box 2307  
Longview, Tex. 75601  
(214) 753-4411

Owatonna Mfg. Co., Inc.  
Box 547  
Owatonna, Minn. 55060  
(507) 451-2860

Prime Mover Co.  
Box 879  
Muscatine, Iowa 52761  
(319) 263-1761

RayGo, Inc.  
9401 85th Ave. North  
Minneapolis, Minn. 55445  
(612) 533-2500

Terex Div.  
General Motors Corp.  
Hudson, Ohio 44236  
(216) 655-5000

Waldon, Inc.  
201 West Oklahoma  
Fairview, Okla. 73737  
(405) 227-3711

Wilmar Manufacturing Co.  
Box 957  
Wilmar, Minn. 56201  
(612) 235-0767

### Skid-steer loaders:

J. I. Case Co.  
700 State St.  
Racine, Wis. 53404  
(414) 636-6562

### Loader buckets:

Loader buckets are standard equipment on most industrial wheel tractors and some crawler-tractors. Separate loader buckets are available from manufacturers or suppliers of construction or excavating equipment.

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 643-2000

Erickson Corp.  
219 St. Anthony Parkway  
Minneapolis, Minn. 55418  
(612) 789-8811

Gehl Co.  
143 East Water St.  
West Bend, Wis. 53095  
(414) 334-9461

HydraMac Inc.  
Box N  
Thief River Falls, Minn. 56701  
(218) 681-7130

International Harvester  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-3874

Melroe Div.  
Clark Equipment Co.  
112 North University Dr.  
Fargo, N.Dak. 58102  
(701) 293-3220

Owatonna Mfg. Co., Inc.  
Box 547  
Owatonna, Minn. 55060  
(507) 451-2860

Sperry New Holland  
500 Diller Ave.  
New Holland, Pa. 17557  
(717) 354-1121

TCI Power Products, Inc.  
900 Ferdig Ave.  
Yankton, S.Dak. 57078  
(605) 665-6500

# Planting Augers

## Function

Planting augers are portable, powered augers to dig holes for planting containerized or bare root seedlings. Larger augers can also dig holes for fence posts.

## Description

A typical planting auger consists of a power unit, a gear box, and the auger bit. The power units may be light-weight chainsaw engines, backpack engines with flexible drive, or separate engines with either flexible or hydraulic drive. The gear box links the power source with the auger bit. Many are adaptable to the chain drive from chainsaw engines. The auger bits have hardened steel base plates. Some bits have rows of brazed carbide along the leading edge for greater durability. Some bits also feature replaceable nose cones.

## Techniques

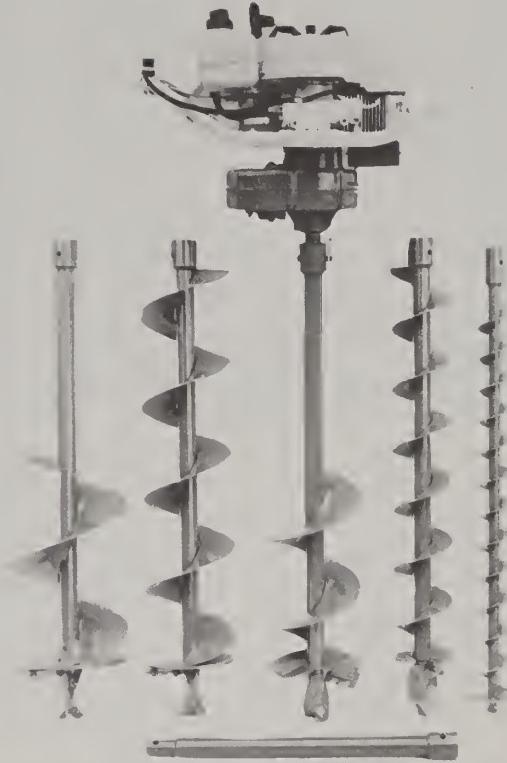
The engine is started and the gear box is engaged. The auger bit cuts into the ground and removes the soil. The hole is drilled vertically to the desired depth. The seedling or fence post is placed in the hole and the loose soil is packed tightly around it, filling in any spaces. One person can easily operate most planting augers, however, some of the larger ones require two people.

## Capabilities

Planting augers enable operators to dig holes quickly and consistently. Large, deep holes can hold larger seedlings. Because the soil surrounding the roots is not compressed, better growth and higher survival is usually obtained. Auger bits are very durable and may be replaced with specialized bits for ice or wood boring.

## Limitations

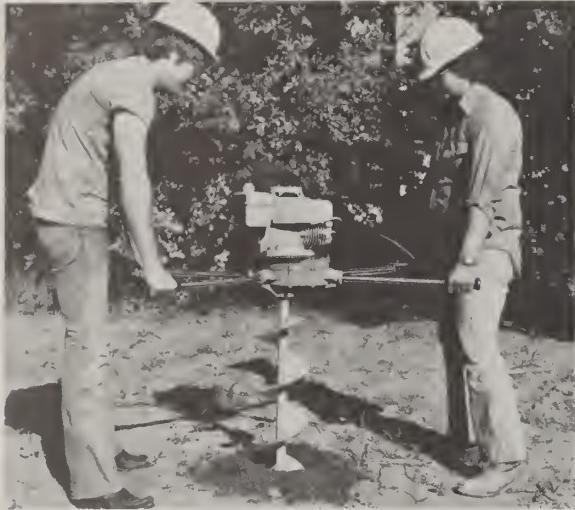
Planting augers are not well suited to areas with many large roots or rocks. They become difficult to operate on areas with extensive surface debris or in clay soils. Fine textured soils tend to settle in the holes leaving the seedling roots exposed underneath.



*Small powered earth auger.*



*Backpack powered earth auger.*



*Large portable auger operated by two people.*

### Specifications

Diameter 1.5 to 18 in (3.8 to 45.7 cm)  
Depth 2 ft to 3 ft 6 in (.6 to 10.7 m) single bit  
to 12 ft (3.7 m) with extensions  
Weight 30 to 86 lb (14 to 39 kg)  
Power ratings 3 to 8 hp (2.2 to 6 kW)

### Availability

Ardisam, Inc.  
Box 666  
Cumberland, Wis. 54829  
(715) 822-2415

Fred A. Lewis Co.  
40 Belknap Rd.  
Medford, Oreg. 97501  
(503) 772-9646

General Equipment Co.  
Box 384  
Owatonna, Minn. 55060  
(507) 451-5510

Ground Hog, Inc.  
Box 290  
San Bernardino, Calif. 92404  
(714) 888-2818

Hoffco, Inc.  
358 Northwest F St.  
Richmond, Ind. 47374  
(317) 966-8161

Little Beaver, Inc.  
Box 840  
Livingston, Tex. 77351  
(713) 327-3121

Stihl, Inc.  
Box 5514  
Virginia Beach, Va. 23455  
(804) 460-3333

## Hand Planting Tools

### Function

Hand planting tools prepare microsites and plant bare-root seedlings. Specialized tools are also available for various sizes of containerized stock.

### Description

Hand planting tools include adze hoes, planting hoes, the Nordplanter, planting bars, and hand planting augers. Dibbles and planting tubes are designed for containerized seedlings.

The adze hoe has a heavy, wide blade for scalping. The planting hoe, sometimes called a hoedad or Rindt hoe, has a long, tapered blade. The blade is flattened or curved inward with a beveled edge for easy penetration. The opposite square end may be used for scalping.

The Nordplanter is a specialized shovel designed for planting. Planting bars are similar to planting shovels except for a wide T-bar handle and a wide, sturdy crossbar for foot placement. The blades are usually flat with sharply beveled edges.

Hand planting augers are simple boring devices that remove soil plugs.

Dibbles and planting tubes are specialized planting tools for containerized stock. Dibbles punch holes in the soil the size of the seedling tubes. Planting tubes displace the soil with a foot lever and place the seedling through the hollow handle.

## Techniques

Adze hoes remove the litter and plant competition from the area surrounding the planting site. Planting hoes dig holes 10 to 12 in (25 to 30 cm) deep and up to 5 in (13 cm) wide. The seedling is placed in the hole and the soil is packed around it. Planting hoes can also scalp the site prior to planting.

The Nordplanter and planting bars are thrust into the soil and rocked back and forth to create a suitable planting hole. When the seedling is placed the tool is again thrust into the soil and pulled back, packing the soil against the seedling roots.

Planting augers are twisted into the soil and pulled out removing a soil core. The seedling is planted in the remaining hole.

Dibbles and planting tubes are driven into the soil, displacing a hole the same size as the type of container used.

## Capabilities

Most seedling planting is with handtools. Planting hoes and planting bars are the most common planting tools. Hoes may prepare the sites as well as plant. Planting bars are often used on rockier sites. Shovels are used for large stock. Handtools are easily packed to remote areas.

## Limitations

Hand planting tools are not well suited to areas with many rocks or extensive brush and debris. They usually require site preparation. Planting bars, dibbles, and planting tubes may cause excessive soil compaction around the seedling, especially in heavy or clay soils. Hand planting is labor intensive and may prove rather costly.



*Adze hoe.*



*Planting hoe.*



*KBC planting bar.*



*Planting tubes.*



*OST planting bar.*



*Dibble with attached scalper.*



*The Nordplanter.*

## Specifications

### Adze hoes:

Blade width 6 to 12 in (15 to 30 cm)  
Handle length 36 in (91 cm)  
Weight 4.5 lb (2 kg)

### Planting hoes:

Blade length 13 to 17 in (33 to 43 cm)  
Blade width 3 to 4 in (7.6 to 10.2 cm)  
Handle length 36 in (91 cm)  
Weight 7.5 lb (3.4 kg)

### The Nordplanter:

Blade length 6 in (15 cm)  
Blade width 3.5 in (8.9 cm)  
Overall length 38 in (97 cm)  
Weight 5 lb (2.3 kg)

### Planting bars:

Blade length 10 to 12 in (25 to 30 cm)  
Blade width 3 to 4 in (7.6 to 10.2 cm)  
Overall length 37 to 42 in (94 to 107 cm)  
Weight 8 to 12 lb (3.6 to 5.4 kg)

### Hand planting augers:

Core diameter 1.5 to 3 in (3.8 to 7.6 cm)  
Length 23.5 to 37.5 (60 to 95 cm)  
Weight 3.5 to 5 lb (1.6 to 2.3 kg)

### Dibbles:

Length 26 to 52 in (66 to 132 cm)  
Weight 4.5 to 7.8 lb (2 to 3.5 kg)

### Planting tubes:

Diameter 1.5 to 2.8 in (3.8 to 7.1 cm)  
Length 36.5 in (93 cm)  
Weight 5.5 to 6.6 lb (2.5 to 3 kg)

## Availability

### Handtools for bareroot seedlings:

A&M Steel Craft  
8250 124th St.  
Surrey, B.C., Canada V3W 3X9

Ames Co.  
Division of McDonough Co.  
Box 1774  
Parkersburg, W.Va. 26101  
(304) 424-3000

Ben Meadows Co.  
3589 Broad St.  
Atlanta, Ga. 30366  
(404) 455-0907

Forestec, Ltd.  
6393 Bayne St.  
Halifax, Nova Scotia, Canada B3K 2V6  
(902) 455-4062

Forestry Suppliers, Inc.  
Box 8397  
Jackson, Miss. 39204  
(601) 354-3565

International Reforestation Suppliers  
Box 5547  
Eugene, Oreg. 97405  
(503) 345-0597

A. M. Leonard, Inc.  
6665 Spiker Rd.  
Piqua, Ohio 45356  
(513) 773-2694

Oregon Reforestation Equipment and Supply  
Box 2597  
Eugene, Oreg. 97402  
(503) 746-2529

TSI Co.  
Box 151  
Flanders, N.J. 07836  
(201) 584-3417

Western Fire Equipment Co.  
440 Valley Dr.  
Brisbane, Calif. 94005  
(415) 467-5650

### Handtools for containerized seedlings:

A&M Steel Craft  
8250 124th St.  
Surrey, B.C., Canada V3W 3X9  
(604) 594-0615

Columbia Plastics, Ltd.  
2155 West 10th Ave.  
Vancouver, B.C., Canada V6K 3H7  
(604) 736-9261

Forestec, Ltd.  
6393 Bayne St.  
Halifax, Nova Scotia, Canada B3K 2V6  
(902) 455-4062

Hakmet, Ltd.  
179 Place Frontenac  
Pointe Claire, Quebec, Canada H9R 4Z7  
(514) 694-4791

International Reforestation Suppliers  
Box 5547  
Eugene, Oreg. 97405  
(503) 345-0597

Oregon Reforestation Equipment  
Box 2597  
Eugene, Oreg. 97402  
(503) 746-2529

Plant-A-Plug Systems  
Division of RCB Corp.  
Box 386  
Crossett, Ark. 71635  
(501) 364-6010

Reid, Collins, and Assoc., Ltd.  
Reforestation Div.  
550 Burrard St.  
Vancouver, B.C., Canada V6C 2K6  
(604) 669-3134

The equipment in this section is for collecting moderate to large amounts of seed. Simple cutting or stripping devices that gather seed in small quantities are not included.

Commercial seed is available and adequate for most purposes. Commercial seed is also carefully controlled and tested for purity and viability.

However, commercially grown seed may not be acceptable for some applications. The increasing demand for native species in strip mine reclamation and rangeland improvement cannot easily be met. In many cases, the desired seed is unavailable because it is difficult to

grow and difficult to harvest economically. Moreover, certain ecotypes may be required that can only be obtained from local stands.

Locally grown seed can provide an economical alternative to purchasing seed. Often, a small stand may supply sufficient seed for rangeland improvements.

Seed must be adequately separated, thoroughly dried, and properly stored to insure quality. Seed processing equipment is not dealt with here, but the collection equipment often does a satisfactory job of separating the seed, and other equipment can be easily constructed to complete the processing procedure.

## Standard Combines

### Function

Standard combines are designed for high-production crop harvesting. They may be useful for large-scale seed collection operations. They can harvest grain or other seed with a minimum of damage.

### Description

A standard combine usually includes: a header assembly; a threshing and separating mechanism; a cleaning unit; a storage bin; power and drive train components; and a control center.

The header assembly consists of a reel, cutting bar, and auger. The header cuts the stems close to the ground and feeds the plant material into the combine.

The threshing and separating mechanism is the heart of the combine. It may consist of either a conventional cylinder followed by straw walkers, or one or two longitudinal rotors. These devices separate the grain or seed from the remaining plant material. The seeds are dropped or conveyed to the cleaning sieves, while the straw and other plant residues are discharged from the combine.

The seed is cleaned by vibrating sieves working in conjunction with airflow from a fan. The light chaff is removed and blown out of the combine. Oversize

material is collected from the sieves and returned to the thresher. The cleaned seed falls through the sieves and is transported to the storage bin for removal.

The grain or seed is finally transferred with a hydraulically powered auger through a chute to a truck.

Most standard combines are self-powered, although a few are towed. A variety of drive train and suspension options allows operation under varying slope and terrain conditions.

The operator monitors and controls all functions from an enclosed, dust-proof cab or from the towing tractor.

### Techniques

The forward speed, header height, cylinder or rotor speed, and air velocity are controlled by the operator to suit various crop conditions. Different crops may be harvested by changing or adjusting components such as the reel, the cutter bars, the concaves or threshing grates, the separating grates, and the sieves.

### Capabilities

Standard combines are well suited for gathering large quantities of seed or grain with minimum damage. The combines can be adapted to different crops or conditions.

## Limitations

Standard combines are expensive agricultural machines, specialized for high-production harvesting. They are not suitable for rocky soil, rough terrain, or steep slopes.



*High-production grain combine.*



*Large rice combine.*

### Specifications

Header width 10 to 24 ft (3 to 7.3 m)  
Storage capacity 80 to 276 cu ft (2.3 to 7.8 m<sup>3</sup>)  
Power ratings 72 to 200 hp (54 to 149 kW)

### Availability

AVCO  
New Idea Farm Equipment  
Coldwater, Ohio 45828  
(203) 552-1800

Allis Chalmers  
Agricultural Equipment Div.  
Box 512  
Milwaukee, Wis. 53201  
(414) 475-2965

Australian Farm Equipment Pty., Ltd.  
1818 Westlake Ave. North  
Seattle, Wash. 98109  
(206) 284-9236

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 693-2000

Horwood Bagshaw  
Box 270  
Clarence Gardens, South Australia 5039  
Australia

International Harvester Co.  
Agricultural Equipment Div.  
401 North Michigan Ave.  
Chicago, Ill. 60611  
(312) 836-2000

Massey Ferguson, Inc.  
1901 Bell Ave.  
Des Moines, Iowa 50315  
(515) 247-2011

Sperry New Holland  
500 Diller Ave.  
New Holland, Pa. 17557  
(717) 354-1121

White Farm Equipment  
White Motor Corp.  
2625 Butterfield Rd.  
Oakbrook, Ill. 60521  
(312) 887-0110

## Small Combines

### Function

Small combines have been developed to gather grain or forage crops from small areas or experimental plots. They may be adapted for collecting moderate amounts of grass seed.

### Description

Small combines are essentially scaled-down standard combines. The headers include plain or pickup-type reels, sickle bar cutters, and augers. Threshing is usually accomplished with rasp bar or spike tooth cylinders. One machine utilizes a belt thresher to harvest wind-rowed legumes and other delicate seed. Various types of sieves are utilized for separation and fans or air nozzles are strategically positioned for cleaning. Cleaned seed is delivered to a collection bin or bagging device by augers or conveyors. Small combines may be self-propelled, towed, or attached to a tractor. Most are self-propelled and hydraulically driven.

### Techniques

As the combine moves over the area, the grass is cut and moved through the header to the feeder. The feeder conveys the cut grass to the threshing cylinder, which separates the seed and seed-size material from the straw. The straw is either ejected automatically or removed by hand. The seed-size material is sifted through sieves and airstreams that remove large particles and light chaff. The cleaned seed is transported to a storage bin where it is removed to be dried and stored.

### Capabilities

Small combines will not efficiently harvest vast areas or large amounts of seed. They are best adapted to grass plants or legumes, and may have to be modified according to the characteristics of the seed collected.



*Small plot combine.*

### Specifications

Header width 13 in to 10 ft (33 to 305 cm)  
Storage capacity to 13 cu ft (357 l)  
Power ratings 5 to 54 hp (3.8 to 40.5 kW)

### Availability

Allan Machine Co.  
Box 112  
Ames, Iowa 50010  
(515) 232-6505

Bill's Welding  
South 700 Grand St.  
Pullman, Wash. 99163  
(509) 567-0771

Carter Manufacturing Co.  
Route 2  
Brookston, Ind. 47923  
(317) 563-3666

Carl Manufacturing Co.  
Box 562  
Twin Falls, Idaho 83301  
(208) 733-7481

Farmax  
Box 8523  
Mobile, Ala. 36608  
(215) 479-8663

Hans-Ulrich Hege, Saatzuchtmashinen  
7112 Domane Hohebuech  
Post Waldenburg (Wurtt)  
West Germany

Kincaid Equipment Manufacturing Corp.  
Box 471  
Haven, Kans. 67543  
(316) 465-3616

Oy W. Rosenlew, Ab  
Metal Industry  
P. L. 51 Box  
28101 Pori 10  
Finland

Walter and Wintersteiger, KG  
A-4910 Ried/Innkers  
Postfach 124  
Austria

For additional Information refer to:

McKenzie, D. W. 1977. Survey of high production seed collectors. USDA Forest Serv. SDEDC ED&T 2632, 18 p., San Dimas, Calif.

## Grass Seed Strippers

### Function

Grass seed strippers strip seed from mature grass plants without cutting the plants. They are mainly for harvesting small, chaffy seeds that are difficult to process with combines.

### Description

Grass seed strippers utilize brushes, beaters, or reels to detach the seeds from the stalks. The seed heads are moved into the stripping mechanism by the action of the mechanism or by an airstream directed towards the mechanism from a blower. The seeds are conveyed mechanically or pneumatically to storage bins or sacks. Grass seed strippers may be self-powered, attached to a tractor, or towed.

### Techniques

The grass seed strippers are moved across a field or between rows of plants. They are mainly used on small areas or experimental plots.

### Capabilities

Grass seed strippers effectively collect small, chaffy seed. They are useful for plants with variable seed size, different rates of maturity, and other growth characteristics that make effective separation difficult.

### Limitations

Grass seed strippers are generally not suited for large-scale seed collection operations. Stripped seeds may require more careful or extensive processing to insure quality.



*Grass seed stripper.*



*Grass stripper reel mounted on a jeep.*

### Specifications

|  |
|--|
| Swath width 2 to 9 ft (.6 to 2.7 m)              |
| Operational height 6 to 48 in (15 to 122 cm)     |
| Storage capacity 10 to 81 cu ft (283 to 2,293 l) |

### Availability

Kincaid Equipment Manufacturing Corp.  
Box 471  
Haven, Kans. 67543  
(316) 465-3616

Lester Gaspar  
2218 West Concho Ave.  
San Angelo, Tex. 76901  
(915) 949-1738

Poynter Products Pty., Ltd.  
52 Greenway St.  
Bulleen, Victoria 3105  
Australia

Information may be obtained from:

Texas Agricultural Experiment Station  
Texas A&M University  
Box 1658  
Vernon, Tex. 76384  
(817) 552-9941

USDA Forest Service  
Shrub Sciences Laboratory  
735 North 500 East  
Provo, Utah 84601  
(801) 377-5717  
FTS 584-0218

# Vacuum Seed Harvesters

## Function

Vacuum seed harvesters collect a wide variety of seed by suction. They can gather small, delicate seeds from low-lying plants or seeds that have fallen to the ground.

## Description

Vacuum seed harvesters are either towed by a tractor or self-propelled. Both types have wide vacuum heads to pick up material in broad swaths.

The towed model is powered by power-take-off from the tractor. It features a threshing cylinder with rasp bars, a cyclone separator, and two sieves. Three fans provide a continuous airflow: the main fan pulls air through the vacuum head, thresher, and cyclone separator; a variable speed cleaning fan is positioned near the sieves; and a seed delivery fan provides the pressure necessary to convey the seed to the storage bin.

The self-powered harvester is hydraulically driven and utilizes an air lock, straw walkers, and a seed tumbler. When the injected material reaches the fan chamber, light material is blown out the air exhaust, while the heavier seed and debris fall to the air lock. The air lock is a rubber paddle-wheel device that rotates, dropping the material onto the straw walkers. The seed and seed-size particles drop through the perforated floor under the straw walkers. This material is then transferred to a seed tumbler for final cleaning and removal.

## Techniques

The vacuum seed harvesters are slowly pulled or driven over the collection area. Fan speeds can be altered and different sieves or straw walker floor plates can be installed for varying seed types.



*Self-powered vacuum seed harvester.*

## Capabilities

Vacuum seed harvesters can effectively harvest fallen seed or seed from low-growing plants. They may be adapted to a variety of small, light seeds.

## Limitations

Vacuum seed harvesters are restricted to flat, fairly level ground. They also require extensive preparation of the harvest areas. The areas must be mowed and raked, with excess material removed, to avoid blockage or other malfunctions within the harvesters. Performance may also be adversely affected if the ground material is wet.



*Towed vacuum-operated seed harvester.*

## Specifications

### Towed model:

Vacuum head width 4 to 7 ft (1.2 or 2.1 m)  
Storage capacity 420 lb (190 kg)  
Power-take-off (PTO) speed 540 rpm  
Power requirements (drawbar) 45 hp (34 kW)

### Self-propelled model:

Vacuum head width 5 ft (1.5 m)  
Storage capacity 5.6 cu ft (118 l)  
Power rating 86 hp (64 kW)

## Availability

### Towed Model:

Australian Farm Equipment Pty., Ltd.  
1818 Westlake Ave. North  
Seattle, Wash. 98109  
(206) 284-9236

Horwood Bagshaw, Ltd.  
Box 270  
Clarence Gardens, South Australia 5039  
Australia

### Self-propelled model:

Bowie Industries, Inc.  
Box 931  
Bowie, Tex. 76230  
(817) 872-2286

This section covers hitches and other equipment for attaching implements to prime movers. Some of the hitches are designed for specific implements or equipment, while others have broader applications. Well-designed hitches contribute to the efficiency of many operations by simplifying hookup procedures, by saving time when turning or transporting implements,

and by providing the capability of treating more land with each pass. Certain hitches enable fewer passes over the land with heavy equipment and reduce the probability of soil compaction and the breakdown of soil structure. Some of the equipment in this section also enhances the safety of equipment operation.

## Pullmeter

### Function

The pullmeter measures the amount of drawbar pull between the tractor and any towed implement. By using the pullmeter and tractor speed, power requirements can be accurately determined.

### Description

The pullmeter is a sealed hydraulic cylinder with a pressure gage attached. The piston head has a 10-square inch ( $65 \text{ cm}^2$ ) area to allow easy calculation of the actual drawbar pull, using English measurements.

### Techniques

The pullmeter is linked between the tractor and towed implement. The tractor pulls the implement a short distance to obtain a reading. The pullmeter readings are then used to calculate the drawbar pull.

Power requirements and production rates are easily determined from the drawbar pull and tractor speed using a simple conversion table (appendix C).

### Capabilities

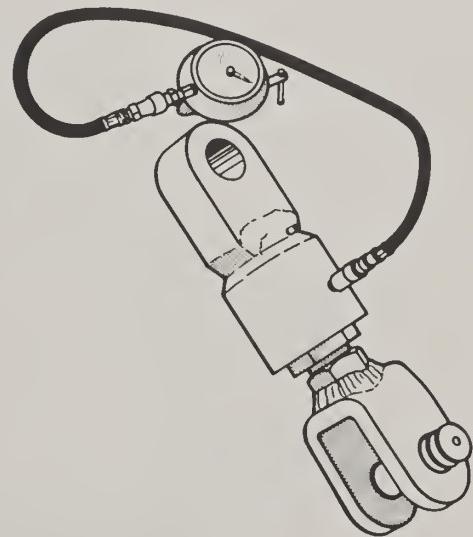
The pullmeter can be used to determine power requirements under varying soil conditions. It may be discovered that a tractor's potential power is not fully utilized or that the amount of pull required under given conditions necessitates a slower speed and results in a lower production rate.

#### Specifications

Tractor attachment - standard clevis pin  
Maximum pull 50,000 lb (22,680 kg)

### Limitations

The pullmeter cannot be used on tractor-mounted implements. Widely fluctuating amounts of pull, such as when overcoming inertia or when obstacles are encountered, result in an average reading that may require an additional margin for safety or efficiency.



*Pullmeter for determining drawbar pull under field conditions.*

#### Availability

Towner Manufacturing Co.  
Box 6096  
Santa Ana, Calif. 92706  
(714) 542-6767

## Folding Toolbars

### Function

Folding toolbars allow easy transport of toolbar-mounted implements through narrow gates or along roads.

### Description

Folding toolbars usually consist of a center section and two wings. Hydraulic cylinders raise and lower the wings. The main section may be mounted on the tractor or towed. Towed models are equipped with wheels and tractor-mounted models may have lift-assist wheels that are raised and lowered hydraulically for easy transport.

### Techniques

A variety of implements, including spike harrows, field cultivators, row crop cultivators, or unit planters, may be mounted on folding toolbars. The hydraulic control can adjust the position of the implements when traversing uneven ground.

### Capabilities

Folding toolbars are suited to implements with light drafts. They enable operators to treat broad swathes of land without encountering transport problems.

### Limitations

Folding toolbars are generally constructed for secondary tillage implements, cultivators, or unit planters. They are not suitable for heavier primary tillage or control implements.

### Specifications

Tractor attachment three-point hitch  
Overall width 16 to 42 ft (2.9 to 12.8 m)  
Transport width 8 to 22 ft (2.4 to 6.7 m)

### Availability

Folding toolbars or frames are standard with many farm implements. They are available from many farm implement manufacturers and farm equipment dealers.



*Folding toolbar equipped with unit planters.*

## Crawler Tractor Toolbars

### Function

Crawler tractor toolbars allow heavy land-forming or tillage implements to be pulled by a crawler tractor. Subsoilers, sweeps, trenches, and bedders are often attached to crawler-tractor toolbars.

### Description

Crawler tractor toolbars are mounted on draft arms that attach to the track roller carriage. The draft arms move freely from side to side, and some can be rotated laterally to the front of the tractor to mount a dozer blade. The toolbar is raised and lowered hydraulically, and its pitch can be adjusted manually.

### Techniques

Various implements are attached to the toolbar and pulled by the crawler tractor. The draft arms are mounted on the track roller carriage to reduce side draft and allow the operating depth to remain fairly constant as the tractor pitches over uneven terrain.

### Capabilities

Crawler tractor toolbars allow subsoilers, small root plows, trenchers, and various other implements to be pulled with powerful crawler tractors, increasing production rates. Toolbars also increase crawler tractor versatility.

### Limitations

Speed and force of the pull must be held within the limits of the implement. Excessive power may result in breakage and downtime.

### Specifications

Tractor attachment-track roller carriage.  
Length 10 to 18 ft (3 to 5.5 m)  
Size 4½ x 7 to 7 x 9 in (11 x 18.6 m or 18 x 23.6m)  
Weight 1,185 to 3,500 lb (536 to 1,590 kg)



*Subsoilers attached to a crawler tractor toolbar.*

### Availability

Caterpillar Tractor Co.  
100 Northeast Adams  
Peoria, Ill. 61629  
(309) 675-1000

Rome Industries  
Box 48  
Cedartown Ga. 30125  
(404) 748-4450

Towner Manufacturing Co.  
Box 6096  
Santa Ana, Calif. 92706  
(714) 542-6767

# Three-Point Hitches for Crawler Tractors

## Function

Three-point hitches for crawler tractors provide an easy method of attaching toolbars or three-point mounted farm implements to crawler tractors.

## Description

The three-point hitches are attached to the rear of the crawler tractor. The operation height can be adjusted with the two bottom brackets, and the pitch is adjusted by the top brace. Lateral sway is limited by two cross chains. The three-point hitches are lifted with dual hydraulic cylinders that can also apply a limited amount of down pressure.

## Techniques

Various implements attach directly to the three-point hitch. Three-point mounted toolbars can carry tillage or land-forming equipment. The three-point hitch easily raises the attached implements to turn or avoid obstacles.

## Capabilities

Three-point hitches increase the versatility of crawler tractors by allowing the attachment of standard three-point implements.

## Limitations

Light duty farm implements should be operated carefully to prevent breaking the hitch and implement under the more demanding conditions that may be encountered with crawler tractors. Depth control is difficult on uneven terrain and sharp turns are not possible with the implement in the ground. The hitches may not be able to withstand operation on rough ground.



*Three-point hitch for crawler tractors.*

## Specifications

Tractor attachment bolted to differential housing  
ASAE Category II or III  
Ground clearance 8 in (20 cm) minimum  
Top pin height 36 in (91 cm) minimum  
Weight 425 to 890 lb (193 to 404 kg)

## Availability

Rome Industries  
Box 48  
Cedartown, Ga. 30125  
(404) 748-4450

Towner Manufacturing Co.  
Box 6096  
Santa Ana, Calif. 92706  
(714) 542-6767

# Implement-Carrying Hitch

## Function

The implement-carrying hitch was developed to attach specialized implements such as fireplows, trenchers, and tree planters to a crawler tractor. It can carry or pull a variety of other implements as well. The design allows an implement to maintain the desired working depth as the tractor pitches over rough or uneven terrain. It also enables the operator to apply down pressure on the implement.

## Description

The implement-carrying hitch has a large kingpin mounted vertically on a frame attached to two draft arms. The draft arms are attached near the center of the track roller carriage. The vertical and lateral positions of the implement are controlled with hydraulic cylinders. These controls have float positions that enable the cylinders to absorb shock. The pitch of the implement is adjusted by a hydraulic cylinder without the float feature.

## Techniques

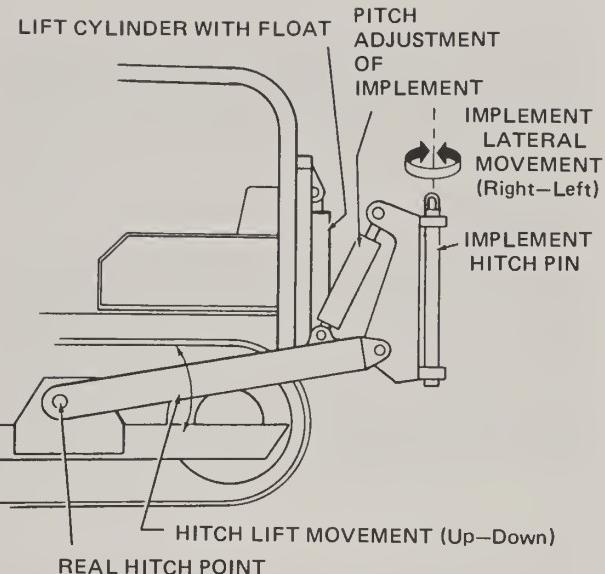
By mounting the draft arms on the track roller carriage, the attached implement can remain in the ground as the tractor negotiates uneven terrain. The implement-pitch adjustment controls the depth when the lift control is in the float position. The kingpin allows the implement to rotate horizontally without excess side draft and enables the operator to turn sharply without lifting the implement from the ground.

## Capabilities

The implement-carrying hitch can carry a variety of implements for forest and range work. The design allows simple and effective control of the implement.

## Limitations

Many implements must be modified for a kingpin hitch. The implement carrying hitch is not commercially available and must be custom-made.



*Implement-carrying hitch.*

## Specifications

Tractor attachment track roller carriage and single rear hydraulic cylinder  
Kingpin diameter 2 in (5.1 cm)  
Kingpin length 20 in (51 cm)  
Weight (down pressure) 1,500 to 3,000 lb (675 to 1,350 kg)

## Availability

Drawings and information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

## Hitch for Tandem Brushland Plows

### Function

With a special hitch arrangement, one tractor can pull two or three brushland plows, enlarging the treatment area of each pass and utilizing available tractor power more efficiently.

### Description

The front hitch assembly of the lead plow is replaced with a connecting link and a spreader bar. Chains connect the tractor to the spreader bar and to the hitch strut of the plow frame. The drawbar of the rear plow is replaced with a special coupling that is pinned to the tailwheel frame of the lead plow. A chain choke is installed on the leading chains to prevent contact with the crawler tracks.

### Techniques

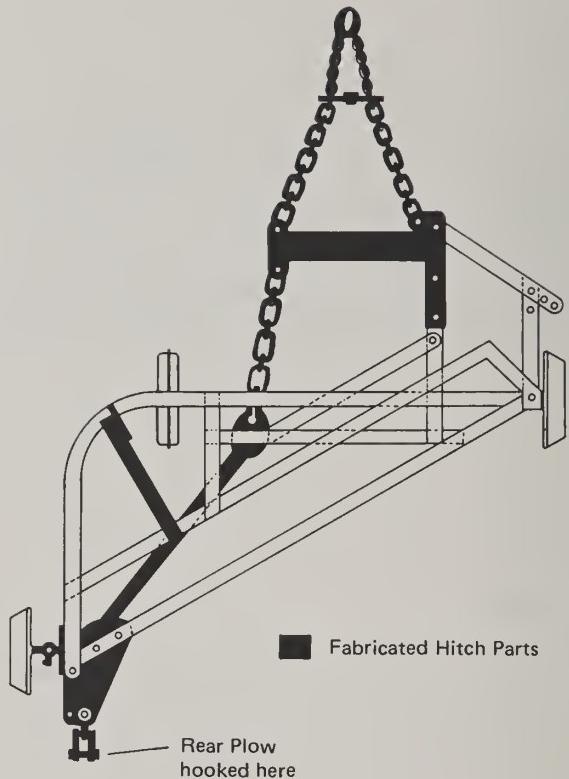
The cutting angle is adjustable from 30 to 40 degrees, depending on the position of the steering draglink. The chains should be inspected to make sure there are no twists that may result in breakage when stressed. Areas should be plowed using only left-hand turns because right turns will result in missed areas.

### Capabilities

The hitch arrangement for tandem brushland plows allows a greater area to be treated with each pass, reducing costs and increasing the efficiency of the plowing operation.

### Limitations

The multiple plow arrangements require more power to operate effectively.



*Hitch for tandem brushland plows.*

### Specifications

Tractor attachment dual lead chain  
Power requirements (drawbar):  
100 hp (75 kW) recommended tandem  
125 hp (93 kW) recommended triple  
Cutting width 19 ft 2 in to 27 ft 9 in (6.2 to 9.3 m)

### Availability

Drawings and Brushland Plow Service and Parts Manuals are available from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

# Multiple Hitches for Rangeland Drills

## Function

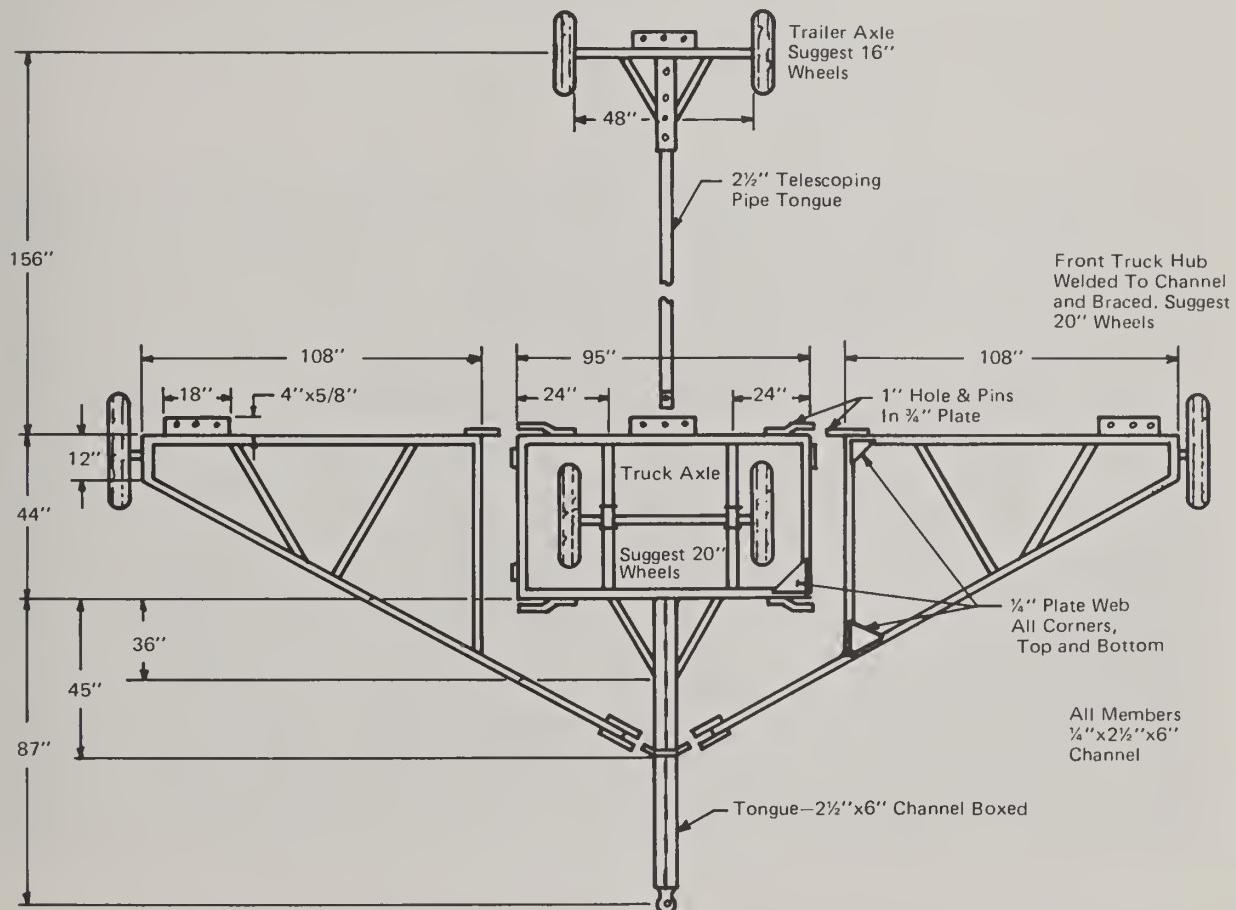
Hitches for two or three rangeland drills have been developed by the USDI Bureau of Land Management (BLM). Simple crossbar-type dual hitches are commercially available. The hitches provide the capacity for seeding land more quickly than single drill arrangements. Multiple drills help reduce seeding costs while retaining the advantages of drilling.

## Description

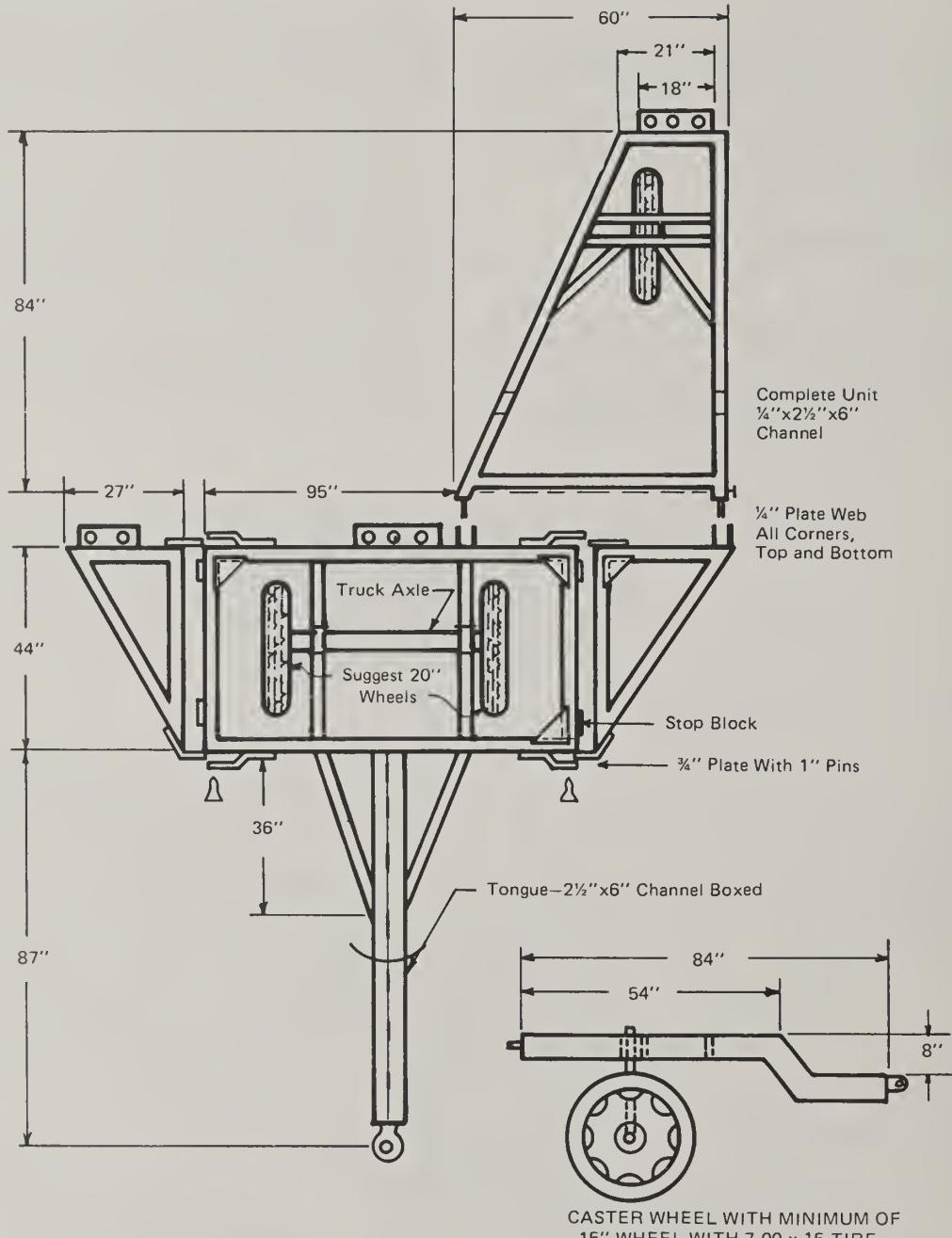
The BLM hitch designs utilize a common cart to which various wings and trailers are attached to give two or three drill configurations. The cart has a sturdy tongue and frame supported by two 20-inch (51 cm) wheels mounted on a single truck or trailer axle. The two-drill

hitch has short, 27-inch (69 cm) wings and a single-wheel trailer that are attached to the cart with 1-inch (2.5 cm) pins. The three-drill hitch has two 108-inch (274 cm) wings pinned to the cart and supported by 20-inch (51 cm) wheels on the outside. A two-wheel trailer with a long telescoping pipe tongue attaches to the rear of the cart. The trailer wheels are 16 inches (41 cm) in diameter. The rangeland drills are attached to the ends of the wings or to the trailers with standard trailer hitches or by special universal hitches for rangeland drills that utilize a swivel-type design for greater freedom of movement.

Another dual hitch utilizes a simple crossbar set at an angle to the drawbar and supported by end wheels. The drills are attached to the hitch by the drill's standard hitch.



*Cart and hitch configuration for three rangeland drills.*



*Cart and hitch configuration for two rangeland drills.*

## Techniques

The multiple drills are attached to the hitch and pulled over the area to be seeded. The wing and trailer attachments are flexible to allow the drills to follow uneven terrain. Crossbars or rigid braces keep the drills in place when operating on steep or hilly land.

## Capabilities

Multiple drill hitches dramatically increase production rates for rangeland drilling operations. With increased production, drilling large areas of land becomes more feasible because of lower cost. The flexibility of the hitches allows the drills to follow uneven terrain. The crossbar hitch is simple and economical.

## Limitations

Two- or three-drill arrangements are somewhat more difficult to operate than a single rangeland drill. Multiple drills also require more tractor power. Some multiple-drill hitches only allow turns in one direction. Crossbar hitches have a more limited range of motion over uneven terrain.

## Specifications

Tractor attachment clevis pin hitch

Power requirements (drawbar):

65 hp (48 kW) dual

90 hp (67 kW) triple

Working width 10 to 30 ft (3 to 9.1 m)

## Availability

Laird Welding and Manufacturing Works  
Box 1053  
531 South Highway 59  
Merced, Calif. 95340  
(209) 722-4145

Information may be obtained from:

USDI Bureau of Land Management  
Vale District Office  
Box 700  
Vale, Oreg. 97918  
(503) 473-3144



*Simple crossbar dual hitch.*

# Hydraulic Dual Hitch

## Function

Hydraulic dual hitches enable hydraulic control of two implements from the tractor. They increase maneuverability in the field and simplify road travel with two implements.

## Description

Hydraulic dual hitches have sturdy frames supported by three wheels. The wheels have 360° casters and the rear wheels can be locked in position, hydraulically, for road travel. Hydraulic control is accomplished by hydraulic cylinders that position the main frame relative to the tongue. For a straight pull, the tongue is located in the field position. A hydraulic crossover relief valve protects the cylinders and the tongue from damage under stress.

The frame is adjustable to accommodate implements of varying width. Hydraulic attachments are provided for the implements. A bumper prevents the front implement from contacting the frame during road travel.

## Techniques

Hydraulic dual hitches enable the operator to position dual implements when turning, or prepare the implements for road travel without leaving the tractor. The hitches allow full hydraulic control of the implements.

## Capabilities

The hydraulic dual hitches provide increased maneuverability and allow transport of various implements. They eliminate the need for readjustment of dual implements in the field. The hitches are useful when treating numerous small areas in close proximity.

## Limitations

Hydraulic dual hitches are designed primarily for pulling farm implements over fairly even terrain. Operation on very rough or steep ground may be more difficult and require more care.



*Hydraulic dual hitch.*

### Specifications

Tractor attachment standard clevis pin hitch  
Power requirements (drawbar) 120 hp (89 kW)  
Working width 9 ft 6 in to 24 ft 4 in (2.9 to 7.4 m)

### Availability

Waldon, Inc.  
201 West Oklahoma  
Fairview, Okla. 73737  
(405) 227-3711

# Chain Swivels

## Function

Chain swivels allow anchor chains to roll and chop instead of slip over vegetation. This increases the destructiveness of the chaining operation by chopping and uprooting the vegetation and by churning the topsoil. The chain action prepares an adequate seedbed for broadcast seeding.

## Description

Although anchor chain swivels are available commercially, they are usually manufactured from D-8 to D-9 Caterpillar track rollers because commercial swivels are either unsatisfactory or much more expensive. Two 1-in (2.5 cm) steel plates are welded to the drum to attach the main chain and a single, 1.5-inch (3.8 cm) steel plate is welded to the roller shaft for lead chain attachment. A grease fitting with a protective cover is installed in the center of the roller to permit lubrication and a collar is welded to the drum for added strength. Sealed rollers are lubricated with a special adapter. All cover plates are left in place to keep out dirt and the shaft bolts are spot welded to prevent them from working loose. Wear points are hardsurfaced to increase durability.

## Techniques

The main chain is attached to the swivel with a 2-inch (5.1 cm) diameter pin between the two plates. A short, smooth lead chain is attached to the swivel with a Navy master connector link. The lead chain permits the operator to back the tractor without running over and damaging the swivel or main chain. For safety, swivel pins and clevis pins are secured with cotter keys, bolts, or spot welds. Frequent lubrication of the swivels, twice daily, helps insure trouble-free service. Permanently sealed bearings are maintenance-free.

## Capabilities

Chain swivels made from D-8 or D-9 track rollers are inexpensive, durable, and very strong. They are capable of withstanding heavy loads over long periods.

## Limitations

The swivels should be sufficiently lubricated and all pins and couplings should be tightly secured to avoid failure and reduce the safety hazard.



*Chain swivel made from a large track roller.*

## Specifications

Swivel mechanism Caterpillar D-8 or D-9  
tractor track rollers

Lead chain length 15 to 25 ft (4.6 to 7.6 m)  
Lead chain weight 40 lb/ft (60 kg/m)

## Availability

Chain swivels can be manufactured in most local machine shops.

Drawings (No. 568) are available from:

USDA Forest Service  
Equipment Development Center  
Building 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157



The equipment in this section transports rangeland or revegetation equipment to and from job sites. It is mainly concerned with trucks and trailers that do not require special equipment to load or unload, such as forklifts or cranes.

Many types of range equipment are equipped for road travel for short distances. However, road travel may be troublesome or time consuming, especially over greater distances. It may also involve legal restrictions. For these reasons, it may prove worthwhile or necessary to load equipment onto trucks or trailers for transport even if the equipment must be partially dismantled and reassembled in another spot.

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## Tilt-Bed Trucks

### Function

Tilt-bed trucks can load and transport equipment such as small tractors, or wheeled implements, that are under 8 feet (1.8 m) wide. These trucks are very versatile, for they can also haul many other items.

### Description

Tilt-bed trucks utilize powerful hydraulic hoists underneath their beds or platforms. These hoists are attached to the truck frames and are usually operated from the cabs. Some tilt-bed truck platforms roll back along the platform frame to the ground for easy loading.

### Techniques

Tractors and wheeled implements are driven or pushed up the inclined bed or platform. Loading ramps or suitable terrain features can facilitate loading where the moderate tilt angles, necessary for easy loading, do not allow the bed to contact the ground. Materials, such as

lumber or fenceposts, that do not have to be reloaded after delivery, can be easily unloaded by tilting the bed and driving forward. All loads should be secured for transport with tie-down chains and chock blocks.

### Capabilities

The tilt-bed feature adds to the versatility of many platform or stake bed trucks, allowing tractors or wheeled implements to be loaded and hauled. The larger hoists have capacities of 25 tons (22.7 metric tons) or more.

### Limitations

Loads must be properly positioned and they must not exceed the load ratings of the trucks. All State and Federal regulations concerning the transport of large loads should apply.

Tilt-bed trucks are generally not suited for large, cumbersome, or very heavy equipment.



*Tilt-bed truck with roll-back platform for easy loading.*

#### Specifications

Platform length 9 to 26 ft (2.7 to 7.9m)  
Platform width 91 to 96 in (2.3 to 2.4 m)  
Hoist capacity 6 to 31 tons (5.4 to 27.5 metric tons)

#### Availability

Flex-Loader  
Div. of Emmepco  
12131 Dorsett Rd.  
St. Louis, Mo. 63043  
(314) 291-6150

#### Henderson Manufacturing Co.

Box 40  
Manchester, Iowa 52057  
(319) 927-2828

Omaha Standard  
2401 West Broadway  
Council Bluffs, Iowa 51501  
(712) 328-7444

Midwest Industries  
Body and Manufacturing Div.  
South Central Ave.  
Paris, Ill. 61944  
(217) 465-6414

Schwartz Manufacturing Co.  
Box 248  
Lester Prairie, Minn. 55354  
(612) 395-2541

## Tilt-Bed Trailers

#### Function

Tilt-bed trailers are platform trailers that tilt back at a moderate angle for easy loading. The trailer platform is pulled level hydraulically for transport.

#### Description

Tilt-bed trailers are available in a variety of sizes and configurations. The tilt mechanisms are hydraulic and may involve a movable undercarriage, an articulated

tongue and frame, or a hoist attached to a rigid frame. On movable undercarriage types, the wheels and axles are moved forward and the unsupported rear portion of the platform is lowered to the ground. With an articulated frame and tongue, the tongue is attached underneath the front half of the platform. A hydraulic cylinder, attached to the center of the tongue, pushes against the front edge of the platform, forcing them apart and tilting the platform. The rigid frame trailers have hoists between the platform and the frame, similar to tilt-bed trucks, which raise the platform. Some tilt-bed trailers are equipped with winches to aid loading.

## Techniques

Tractors or wheeled implements are simply driven or winched up the inclined platform from the ground. Tractor-mounted implements may be hauled separately if they are detached while the tractor is on the trailer.

After the load is positioned, the platform is pulled level and the load is secured for travel. Approximately 15 percent of the weight should rest on the tongue to provide proper load distribution and supply additional traction to the towing vehicle.

## Capabilities

Tilt-bed trailers are easy to load and adequate for light to moderately heavy equipment. They are towed with trucks that provide extra load capacity.

## Limitations

Insure that the load is properly balanced and secured. Loads over 8 feet (1.8 m) wide may require special permits. Speed should be adjusted to the load for safe operation. The towing truck should be of proper size and adequately loaded.

## Specifications

Platform length 11 ft 6 in to 25 ft 4 in (3.5 to 7.7 m)  
Platform width 5 ft 6 in to 8 ft (1.7 to 2.4 m)  
Capacity 4 to 25 tons (3.6 to 22 metric tons)



*Tilt-bed trailer.*

## Availability

Birmingham Manufacturing Co., Inc.  
Box 289  
Springville, Ala. 35146  
(205) 595-6183

Bush Hog Div.  
Allied Products Corp.  
Box 1039  
Selma, Ala. 36701  
(205) 872-6261

Flexi-coil, Ltd.  
Box 1928  
2326 Millar Ave.  
Saskatoon, Sask., Canada S7K 2Y2  
(306) 652-9022

Hyster Co.  
Construction Equipment Div.  
Box 289  
Kewanee, Ill. 61443  
(309) 853-3571

Jacobsen Trailer Co.  
6333 East South Ave.  
Fowler, Calif. 93625  
(209) 834-2409

Lakeside Truck Body Co.  
Box 1104  
Turlock, Calif. 95380  
(209) 632-7501

Miller Tilt Top Trailer, Inc.  
Box 2646  
Muscle Shoals, Ala. 35660  
(205) 381-3820

Transport Trailers  
1200 12th St. SW  
Cedar Rapids, Iowa 52406  
(319) 365-1481

Wisconsin Trailer Co., Inc.  
3090 Polk  
Richfield, Wis. 53076  
(414) 628-1161

Zieman Products  
Box 698  
Whittier, Calif. 90608  
(213) 696-1186

## Standard Flatbed Trailers

### Function

Flatbed trailers have been used extensively to haul many types of equipment. Most standard flatbed trailers are easily towed with conventional trucks.

### Description

Standard flatbed trailers are simple platforms attached to frames. They may have up to three axles with two or four tires per axle. The tongues are usually extensions of the frames. Some flatbed trailers feature gooseneck tongues that attach to fifth-wheel, kingpin-type hitches in the beds of pickup trucks. Most flatbed trailers are equipped with loading ramps, although specialized ramps may have to be provided occasionally.

### Techniques

Equipment is driven or pulled up the loading ramps onto the trailer. The equipment is then blocked, tied down, and otherwise prepared for transport. Forklifts or cranes may facilitate loading.

### Capabilities

Flatbed trailers can be equipped to haul most types of equipment. They are simply designed, sturdily constructed, and reliable. Standard flatbed trailers do not require hydraulic power. Larger trailers can haul up to four rangeland drills at once.

### Limitations

Flatbed trailers may be more difficult to load than tiltbed or lowbed trailers. Safety should be stressed during all loading and unloading procedures. Flatbed trailers should not be used for very heavy or cumbersome equipment.



Flatbed trailer.

### Specifications

Platform length 12 to 40 ft (3.7 to 12.2 m)  
Platform width 6 ft 3 in to 8 ft (1.9 to 2.4 m)  
Capacity 4.5 to 27 tons (4.1 to 24.3 metric tons)

### Availability

Birmingham Manufacturing Co., Inc.  
Box 289  
Springville, Ala. 35146  
(205) 595-6183

Flexi-Coil Ltd.  
Box 1928  
2326 Millar Ave.  
Saskatoon, Sask., Canada S7K 3S5

Dakota Manufacturing Co.  
Box 954  
Mitchell, S.Dak. 57301  
(605) 996-5571

Jacobsen Trailer Co.  
6333 East South Ave.  
Fowler, Calif. 93625  
(209) 834-2409

Rivinius, Inc.  
Rural Rt. 2, Box 63  
Eureka, Ill. 61530  
(309) 467-2303

DEMCO  
North Loop 340  
Box 4308  
Waco, Tex. 76705  
(817) 799-4941

Miller Tilt Top Trailer, Inc.  
450 South 92nd St.  
Milwaukee, Wis. 53214  
(414) 476-4030

Shoals American Industries, Inc.  
Box 2646  
Muscle Shoals, Ala. 35660  
(205) 381-3820

Donahue Corp.  
Box 126  
Durham, Kans. 67438  
(316) 732-2665

Ranch Manufacturing Co., Inc.  
Box 856  
Lamar, Colo. 81052  
(303) 336-9041

Zieman Products  
12425 East Whittier Blvd.  
Box 698  
Whittier, Calif. 90608  
(213) 696-1186

# Lowbed Semi-Trailers

## Function

Lowbed semi-trailers are designed to efficiently load and haul heavy equipment or machinery. They are operated in combination with large semi-tractors and can haul loads up to 75 tons (67 metric tons).

## Description

Lowbed semi-trailers have one to three axles with dual wheels on each side of the axle. The decks may either be level over the axles, or drop down even with the axles. A fifth-wheel kingpin, located under the front platform, or gooseneck, joins the trailer to the tractor. Many goosenecks fold down or detach from the lowbed trailers to facilitate loading and unloading. The goosenecks are repositioned hydraulically or mechanically and locked in place for transport.

## Techniques

When the gooseneck is removed or folded down, the lowbed trailer rests on the ground. Equipment may be driven or pulled onto the bed from the front or, with a small ramp, from the side. Wide, cumbersome implements, such as the brushland plow or large rolling choppers, can thus be loaded with relative ease. The gooseneck is then repositioned, the trailer is raised, the load is secured, and the tractor is attached for transport.

## Limitations

Lowbed semi-trailers require big semi-tractors to operate. They are not well suited for travel on narrow, unimproved roads. All loads should be properly prepared for transport in accordance with State and Federal laws. Special permits are required for oversize loads.

## Availability

Birmingham Manufacturing Co., Inc.  
Box 289  
Springville, Ala. 35146  
(205) 595-6183

Freuhauf Corp. Div.  
10900 Harper Ave.  
Detroit, Mich. 48232  
(313) 267-1000

General Eager Beaver Trailers  
Route 130  
Thorofare, N.J. 08086  
(609) 845-5400

Hyster Co.  
Construction Equipment Div.  
Box 289  
Kewanee, Ill. 61443  
(309) 853-3571

Rivinius, Inc.  
Rural Rt. 2, Box 63 3  
Eureka, Ill. 61530  
(309) 467-2303

Schwartz Manufacturing Co.  
Box 248  
Lester Prairie, Minn. 55354  
(612) 395-2541

Talbert Trailers  
Box 38  
Ransselaer, Ind. 47978  
(219) 866-7141

Transport Trailers  
1200 12th St. SW  
Cedar Rapids, Iowa 52406  
(319) 365-1481

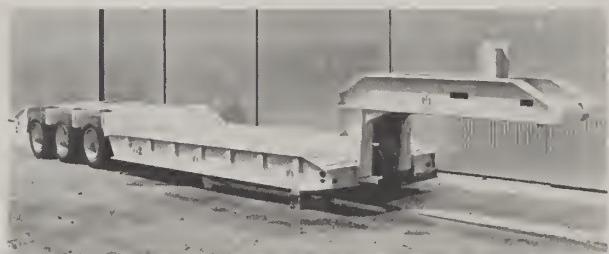
Vulcan Trailer Manufacturing Co.  
Box 5099  
Pratt City Station  
Birmingham, Ala. 35214  
(205) 798-5746



*Lowbed semi-trailer with hydraulically controlled gooseneck in lowered position for loading.*



*Lowbed semi-trailer with hydraulic gooseneck raised for transport.*



*Lowbed semi-trailer featuring a detachable gooseneck.*

## Specifications

Platform length 16 to 20 ft (4.9 to 6.1 m)  
Overall length 27 ft 6 in to 45 ft 8 in (8.4 to 13.9 m)  
Width 8 to 10 ft (2.4 to 3.1 m)  
Capacity 15 to 75 tons (13 to 67 metric tons)

## Flatbed Implement Carriers

### Function

Flatbed implement carriers are designed to transport wide, cumbersome farm implements short distances without disassembly. They are often pulled by the tractor after it is detached from the implements.

### Description

Flatbed implement carriers are long, wide platforms with removable undercarriages that slide along the frame rails. The undercarriages typically have tandem axles, but some have as many as four axles. Two wheels are attached to each axle. The platform frames have standard tractor hitches, jacks, and undercarriage locks.

### Techniques

A flatbed implement carrier is loaded by first locking the wheels and releasing the undercarriage. The platform is then pulled completely off the sliding undercarriage, onto the ground. After the implements are towed into place on the platform, the front of the platform is jacked up and the tractor is reattached. Finally, the tractor pushes the platform back onto the sliding undercarriage, which is locked into position. When the carrier wheel locks are released the load is ready for transport. The unloading procedure is essentially the same.

### Capabilities

Flatbed implement carriers can easily transport various implements, loads of hay, or other materials. They can be pulled with trucks or rubber-tired tractors. They are useful for transporting wide implements that must be disassembled for road travel or trailer transport.

### Limitations

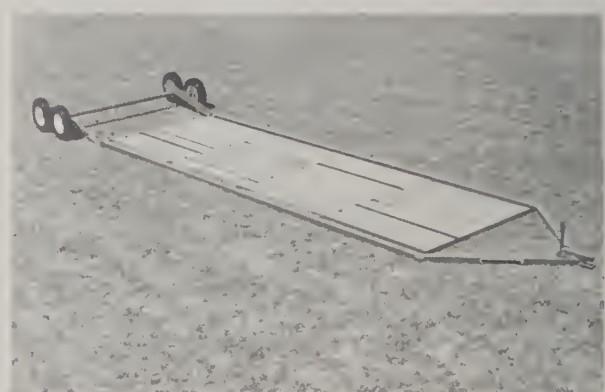
Flatbed implement carriers cannot support very large implements or heavy equipment. They are not suitable for long distance transport or for rough, unimproved roads.

### Specifications

Platform length 21 to 48 ft (6.4 to 14.6 m)  
Platform width 5 to 10 ft (1.5 to 3 m)  
Capacity 4 to 6.3 tons (3.6 to 5.6 metric tons)



*Flatbed implement carrier.*



*Flatbed implement carrier lowered for loading.*

### Availability

Coon Manufacturing and Distributing  
Box 196  
Spickard, Mo. 64679  
(816) 485-6299

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Donahue Corp.  
Box 126  
Durham, Kans. 67438  
(316) 732-2665

# Straddle-Type Implement Carriers

## Function

Straddle-type implement carriers transport heavy, bulky implements, such as the brushland plow and rangeland drill, by suspending them from a wheeled frame.

## Description

The straddle-type implement carrier has a long, high frame with four heavy-duty supports. The supports are attached directly to the wheels in the rear and to an axle in the front. The front axle turns for easier steering and better tracking. A series of cables or chains suspend the implement underneath the frame. A manual or hydraulic winch system shortens or lengthens the chains or cables. The hydraulic system is powered by a separate gasoline engine. The towing tongue has a standard clevis-pin hitch. Tail, stop, clearance, and turn signal lights should be provided for road travel.

## Techniques

The implement is attached to the chains or cables and winched up underneath the frame. The recommended ground clearance is 8 to 10 inches (20 to 25 cm). The implement tongue is lifted and secured with a side winch.

## Capabilities

Straddle-type implement carriers transport large, heavy implements. They can be towed behind trucks or rubber-tired tractors. Loading is usually a simple procedure. The implements can be raised to obtain more ground clearance, if necessary, for travel over rough roads.

## Limitations

Some implements must be partially dismantled prior to loading. The suspended implements may tend to swing underneath the carrier making control of the carrier and towing vehicle more difficult.



*Straddle-type implement carrier.*

## Specifications

Length underneath the frame 20 to 30 ft (6.1 to 9.2 m)  
Width 8 ft (2.4 m)  
Height underneath the frame 5 ft 10 in to 6 ft 6 in (1.8 to 2 m)  
Lift assembly power 8 to 10 hp (6 to 7.5 kW)  
Capacity 2 to 10 tons (1.8 to 9.1 metric tons)

## Availability

Archer Manufacturing Co.  
Box 155  
Knights Landing, Calif. 95645  
(916) 735-6211

Thomas Welding and Machine, Inc.  
1308 West Eighth Ave.  
Chico, Calif. 95926  
(916) 343-5529



This section includes specialized equipment for fence construction, plastic pipe installation, and equipment maintenance. Commonplace material or equipment, such as fence posts, barbed wire, stock tanks, pumps, air compressors, lubricants, or handtools, are not included.

Fences are vital to range management and revegetation. They are most often used to exclude livestock to allow vegetation to recover or become established. Fence construction may utilize a wide variety of materials and designs, depending upon the nature and purpose of the enclosure situation. Three- or four-strand wire fences are commonly used on rangelands. Properly designed, these fences effectively control livestock while allowing relatively unobstructed passage to most other animals.

Plastic pipes are installed to distribute water for drinking or other purposes. Some water developments may be constructed with equipment listed under *Controlling Plants with Equipment or Ground Preparation*. Other water developments require specialized construction or land-forming equipment, such as ditchers, trenchers, scrapers, levelers, backhoes, or drills. Because these machines do not relate directly to revegetation they will not be discussed.

Many maintenance tools and techniques, although important for effective and efficient equipment operation, are, likewise, beyond the scope of this handbook.

## Fury Fence-Building Machine

### Function

The Fury fence-building machine drives posts, dispenses wire, and stretches wire. It erects posts and fence in a single operation. It operates most effectively on even terrain and moderate slopes.

### Description

The Fury fence-building machine is towed behind a farm tractor. The post driver and wire stretchers are hydraulically operated. The machine can stretch up to four strands of wire and woven wire simultaneously through an elaborate system of pulleys and clamps. The Fury fencer can also haul an ample supply of posts and corner assemblies.

### Techniques

Three people are required to operate the machinery: one drives the tractor, one operates the post driver, and one handles supplies. The fence line should be prepared in advance by blading and marking. Up to 1 mile (1.6 km) of fence can be constructed per day.

### Capabilities

The Fury fence-building machine erects posts and fence in a single operation. It can be towed almost anywhere the tractor can go. The Fury fencer can handle most types of wire fencing and can be adjusted to different design specifications.

## Limitations

The Fury fence-building machine was designed for farmland and is most efficient when erecting straight fences on level ground and even terrain. Some problems have been encountered when fencing contours on slopes over 20 percent.



*Fury fence-building machine.*

### Specifications

Capacity 4 wire strands and wire mesh  
Height to 5 ft (1.5 m)  
Hydraulic capacity 12 to 15 gal per min (45 to 57 l/min)  
Power requirements (drawbar) 60 to 80 hp (45 to 60 kW) recommended

### Availability

Somerset Welding and Steel Corp.  
Box 628  
Somerset, Pa. 15501  
(814) 443-2671

## Post Hole Diggers

### Function

Post hole diggers dig large holes in the ground for fence post placement.

### Description

Post hole diggers are large augers that are powered by hydraulic systems or by power-take-off. They are raised and lowered manually or hydraulically and are usually mounted on a tractor or a small front-end loader. Various auger suspension devices insure vertical placement. The auger shafts are attached with shear bolts to prevent damage to the drive train if the auger rotation is stopped suddenly by an obstruction.

### Techniques

The post hole digger is positioned by the operator and the rotating auger is lowered into the ground to dig the post hole.

### Capabilities

Post hole diggers enable operators to quickly erect fence posts. The holes can be placed in moderately rocky soil. Slopes up to 20 percent and moderately rugged terrain can be negotiated by most tractors. Post hole diggers also may be used in some transplanting operations.

### Limitations

The augers may be damaged when encountering large rocks. The ground must be tamped around the posts for a secure installation.

### Specifications

Diameter 4 to 36 in (10 to 91 cm)  
Depth to 50 in (127 cm)  
Power requirements 20 hp (15 kW) minimum



*Hydraulic post hole digger.*

### **Availability**

Arps Div. of Chromalloy  
1711 Wisconsin Ave.  
New Holstien, Wis. 53061  
(414) 898-4291

Austin Products Inc.  
Service Div.  
Box 222117  
Dallas, Tex. 75222  
(214) 651-0733

Cherokee Farm Machines Co.  
Box 646  
Sioux City, Iowa 51102  
(712) 258-4528

Continental Belton Co.  
Box 660  
Belton, Tex. 76513  
(817) 939-3731

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Farnum Equipment Co.  
Box 21447  
Phoenix, Ariz. 85036  
(602) 244-8261

Ford Tractor Operations  
2500 East Maple Rd.  
Troy, Mich. 48084  
(313) 643-2000

Independent Manufacturing Co., Inc.  
Box 300  
Neodesha, Kans. 66757  
(316) 325-3061

Massey Ferguson  
1901 Bell Ave.  
Des Moines, Iowa 50315  
(515) 247-2011

McMillen Div.  
States Engineering Corp.  
4419 Ardmore Ave.  
Fort Wayne, Ind. 46809  
(219) 747-6195

Napier Grasslands Pty., Ltd.  
Box 244  
Taree, NSW, 2430  
Australia

Rears Manufacturing Co.  
2140 Prairie Rd.  
Eugene, Oreg. 97402  
(503) 688-1002

Shaver Manufacturing Co.  
Box 358  
Graettinger, Iowa 51342  
(712) 859-3536

## Post Drivers

### Function

Post drivers provide a practical and economical way of setting wood or steel fence posts. They are easy to use and effective in most soil conditions.

### Description

Most post drivers are small piledrivers that drive fence posts by repeatedly dropping a heavy weight on them. They are mounted on the front or rear of a tractor or on a small two-wheeled trailer. They can be powered hydraulically, with power-take-off, or by a separate gasoline engine.

A small, hand-portable unit is available that utilizes a rapidly reciprocating piston powered with compressed air.

### Techniques

After being positioned, the post driver drives the post into the ground with a heavy weight. The power source lifts the weight, which is then dropped onto the fence post. This is rapidly repeated until the post is driven to the desired depth. Production rates of 30 posts per hour have been reported for two person crews.

The air-powered driver is placed on top of the post with an appropriate adapter. The post is driven by the repeated impact of the piston.

### Capabilities

Post drivers can be operated on most soils of sufficient depth. The trailer models are very mobile, but the tractor-mounted models are limited to the slope and terrain capabilities of the tractor.

Air-powered units are very lightweight and portable.

### Limitations

Fence posts should normally be driven at least 2 feet (.6 m) into the ground. Posts may be very difficult to drive into frozen or rocky ground. Air-powered post drivers require a nearby air compressor and cannot drive posts over 4 in (10 cm) in diameter.



*Power-take-off post driver mounted on a three-point hitch.*



*Front-mounted post driver.*



*Post driver mounted on a separate trailer.*

### Specifications

#### Conventional post drivers:

Post length to 10 ft (3 m)  
Post diameter to 8 in (20 cm)  
Power requirements (drawbar) 20 hp (15 kW)  
minimum

#### Air-powered post driver:

Post length to 20 ft (6.1 m)  
Post diameter to 4 in (10 cm)  
Air pressure required 90 to 100 psi  
(620 to 689 kPa)



*Air-powered post driver.*

### Availability

#### Conventional post drivers:

Cartner Corp.  
Box 262  
Cambridge, Ohio 43725  
(614) 439-2725

Cherokee Farm Machines, Co.  
Box 656  
Sioux City, Iowa 51102  
(712) 258-4528

Danuser Machine Co.  
500 East Third St.  
Fulton, Mo. 65251  
(314) 652-2246

Deere and Co.  
John Deere Rd.  
Moline, Ill. 61265  
(309) 752-8000

Farnum Equipment Co.  
Box 21447  
Phoenix, Ariz. 85036  
(602) 244-8261

Flexi-Coil, Ltd.  
Box 1928  
Saskatoon, Sask., Canada S7K 3S5

McMillen Div.  
States Engineering Corp.  
4419 Ardmore Ave.  
Fort Wayne, Ind. 46809  
(219) 747-6195

Shaver Manufacturing Co.  
Box 358  
Graettinger, Iowa 51342  
(712) 859-3536

Air-powered post driver:  
Rhino Sales Corp.  
Box 367  
620 Andrews Ave.  
Kewanee, Ill. 61443  
(309) 853-4461

## Post Extractors

### Function

The post extractor easily removes damaged or broken fence posts. Adapters are available to fit most types of fenceposts.

### Description

Post extractors are basically large hydraulic jacks mounted in the center of sturdy, V-shaped stands. An upright support is attached to the apex, and two braces connect the top of the upright support to the ends of the stand. A lift arm is attached to the top of the upright support and is connected to the hydraulic jack. A chain and hook are located at the end of the lift arm to wrap around the posts or attach various adapters.

### Techniques

The ends of the V-shaped stand are placed around the post to be removed and the chain or an adapter is secured to the post. The operator works the hydraulic jack, which raises the lift arm to pull out the post.

### Capabilities

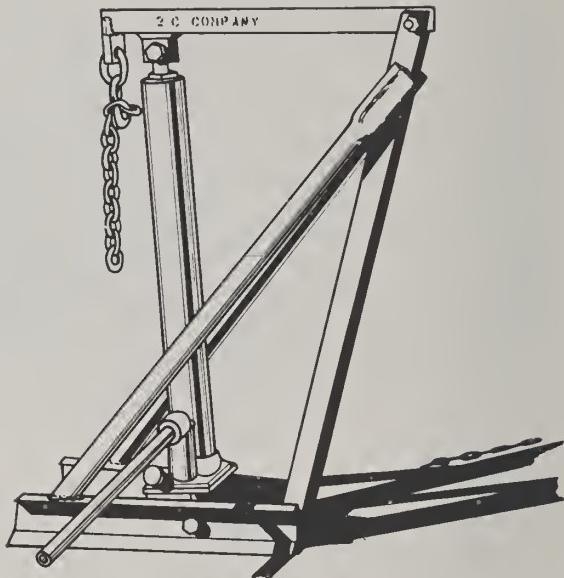
Post extractors are simple devices that quickly and easily remove damaged fenceposts, usually without digging.

### Limitations

Post extractors are heavy and somewhat cumbersome. They may be difficult to carry to remote sites without a vehicle.

### Specifications

Lift capacity 6,000 pounds (2,700 kg)  
Weight 68 pounds (31 kg)



*Portable post extractor.*

### Availability

2C Co.  
Box 262  
Cambridge, Ohio 43725  
(614) 439-2725

Little Beaver, Inc.  
Box 840  
Livingston, Tex. 77351  
(713) 327-3121

# Reel Tite Fence Tighteners

## Function

Reel Tite fence tighteners tighten wire fences without unstapling and restretching. They eliminate much of the labor required for fence maintenance and may be used effectively on most types of wire fence, in almost any condition.

## Description

Reel Tite fence tighteners are small metal plates with two pegs to wrap the wire, four notches to hold the tightener in place, and a loop and pin to attach the handle for leverage.

## Techniques

A simple L-shaped handle is attached to the tightener loop and held in place with a retainer pin. The fence wire is placed between the two pegs on the opposite side of the tightener. The handle is cranked in a circle, winding the wire around the pegs. When the desired tension is reached, one of the notches around the circumference of the tightener catches the standing wire and holds the tightener in place. The handle and retaining pin are removed.

## Capabilities

Reel Tite fence tighteners can hold up to 12 in (30 cm) of wire each. One tightener per wire can tighten up to 1000 ft (305 m) of fence. However, more may be needed, depending on the amount of slack and the terrain. Reel Tite tighteners can also pull slack out of splices. The wire does not need to be unstapled and restretched at the corners. Reel Tite tighteners can be used on old rusty wire, electric wire, or woven wire.

## Limitations

Wire in very poor condition should probably be replaced.

### Specifications

Reel capacity to 12 in (30 cm) of wire  
Length of fence 200 to 1000 ft (60 to 305 m) per tightener

*Reel tite fence tightener.*



### Availability

Kermco Products  
Rt. 1, Box 204  
Monroe, Iowa 50170  
(515) 259-2987

# Plastic Pipe-Laying Machines

## Function

Plastic pipe-laying machines rapidly lay plastic pipe or cables underneath the ground.

## Description

Plastic pipe-laying machines consist of large reels to hold the pipe, a device to penetrate the ground, and a shoe to guide the pipe into position.

The original design was a modified towed ripper. A shoe was attached to the ripper shank and a large reel was mounted on the towed unit above the shoe. The shoe consisted of a 3-inch (7.6 cm) diameter steel tube bent into a curve with a 16-inch (41 cm) radius. The tube was attached to the ripper with steel plates. The reel had a flange on one side with collapsible spokes on the other to permit easy loading of the pipe coils. Drag chains fill in the trench to cover the pipe.

Cable plows can be adapted or modified for plastic pipe installation. The curve in the shoe must be gradual enough to accommodate the more rigid plastic pipe. The units should lay pipe up to 2 inches (5.1 cm) in diameter.

Another method for plastic pipe installation utilizes a simple reel mounted horizontally on a truck bed or platform. The reel is welded to an automobile wheel hub assembly with the brake intact to control the tension of the pipe during installation.

## Techniques

A two- or three-member crew is required for plastic pipe-laying operations. With ripper shank or cable plow units, one person operates the tractor while the others load the pipe coils and splice the sections. With the horizontal reel, the pipe is guided into a trench or ditch that is dug by a grader or three-way dozer. A second pass with the grader or dozer covers the pipe.

## Capabilities

Ripper shank or cable plow units can lay plastic pipe easily, and very quickly. The horizontal reel is a simple, reliable device that provides an economical alternative to the other machines.

## Limitations

Care should be taken to prevent backlash on the reels, which damages the pipe. In rocky soils, the trenches may have to be previously ripped.



*Cable plow with full hydraulic control.*



*Towed ripper modified for laying plastic pipe.*

## Specifications

### Ripper shank or cable plow units:

Pipe diameter 1 to 2 inches (2.5 to 5.1 cm)  
Depth to 42 inches (107 cm)

### Horizontal reel:

Depth to 18 inches (45.7 cm)

## Availability

Towed ripper unit and horizontal reel drawings (RM21-01 to 03 and RM24-01) are available from:

|  |  |   |
|--|--|---|
| USDA Forest Service<br>Equipment Development Center<br>444 East Bonita Ave.<br>San Dimas, Calif. 91773<br>(714) 599-1267 or (213) 332-6231<br>FTS 793-8000 | CRC - Kelley Products<br>Box 4700<br>Brownsville, Tex. 78520<br>(512) 546-5346 | Seaman Co.<br>Box 25331<br>Milwaukee, Wis. 53225<br>(414) 781-8900          |
| Cable plows:<br><br>American Tractor Equipment Co.<br>9131 San Leandro St.<br>Oakland, Calif. 94603<br>(415) 638-2466                                      | J. I. Case Co.<br>700 State St.<br>Racine, Wis. 53404<br>(414) 636-6011        | Vermeer Manufacturing Co.<br>Box 200<br>Pella, Iowa 50219<br>(515) 628-3141 |

## Plastic Pipe Fusion Machines

### Function

The plastic pipe fusion machines weld sections of polyethylene pipe. With proper techniques, the welds are as good as, or better than joints made with inserts and clamps. The welded pipe is easy to feed through pipe-laying machines, and no clamps are installed that may rust or work loose, causing failure.

### Description

Plastic pipe butt-welding machines consist of two clamps mounted on parallel bars in a frame. One clamp slides along the bars so the pipe ends can be precisely aligned and can simultaneously contact the removable heating plate. The heating plate has an electrical heating element and a thermometer. The temperature setting can be adjusted with a thermostat. A heater storage unit, a tubing cutter, and a set of clamp inserts for each size of pipe are also required.

Socket fusion machines are also available that utilize socket couplings or collars over the joint. These machines are similar to butt welding devices except that they do not require a frame.

### Techniques

Best results are obtained when the plates are heated to between 450 and 500° F (232 to 260° C). The pipe is cut, clamped in the frame, and held against the heater plate until a small bead appears. When the bead is about 1/16 in (1.6 mm), the heater plate is removed and the pipe ends are pressed firmly together for about 30 seconds to form the weld.

The socket fusion equipment is operated by camphoring the inside of the pipe, installing the clamp a measured distance from the end of the pipe, and inserting the pipe and the plastic socket on the opposite faces of the heater plate. When the appropriate temperature is reached, the pipe and socket are removed from the heater plate and slipped together. Another section of pipe is fused to the opposite end of the socket to complete the joint.

### Capabilities

Plastic pipe fusion machines can produce strong, reliable welds in polyethylene pipe. The machines are most useful and economical on large projects where several miles of pipe are laid by machine.

## Limitations

Plastic pipe fusion equipment requires a portable generator to provide electricity in the field. For consistent results, fusion temperatures between 450 and 500° F (232 to 260° C) should be maintained. Although these machines will weld polyvinyl chloride (PVC) pipe, adhesives are recommended for this material.

The socket-fusion method is more difficult and time-consuming than butt-welding. It also requires a precise fit between the socket couplings and the pipe that may be difficult to attain with some types and sizes of pipe.

## Specifications

### Butt-welding machines:

Pipe size .5 to 2 in (1.3 to 5.1 cm) CTS or 1 to 4 in (2.5 to 10.2 cm) IPS outside diameter controlled  
Temperature range 300 to 600° F (149 to 316° C),  
450 to 500° F (232 to 260° C) recommended  
Power requirements 1 kW portable ac generator

### Socket fusion equipment:

Pipe size to 2 in (5.1 cm) outside diameter  
Temperature range 340 to 500° F (171 to 260° C),  
450 to 500° F (232 to 260° C) recommended  
Power requirements 1 kW portable ac generator

## Availability

### Butt-welding machines:

McElroy Manufacturing, Inc.  
5619 East Independent St.  
Tulsa, Okla. 74115  
(918) 836-8611

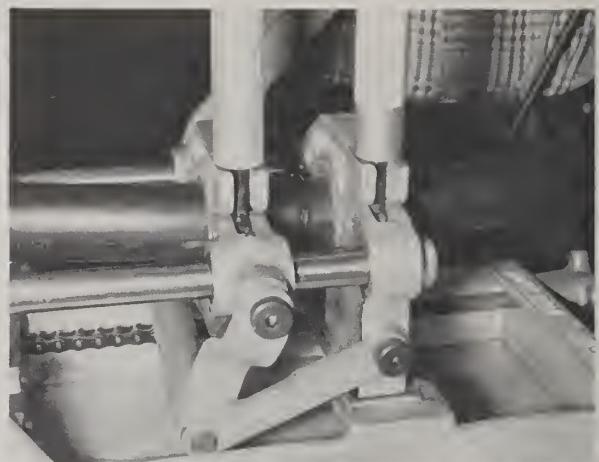
P&S Engineering Div.  
Ridge Tool Co.  
Box 1051  
Bartlesville, Okla. 74003  
(918) 336-5006

### Socket fusion equipment:

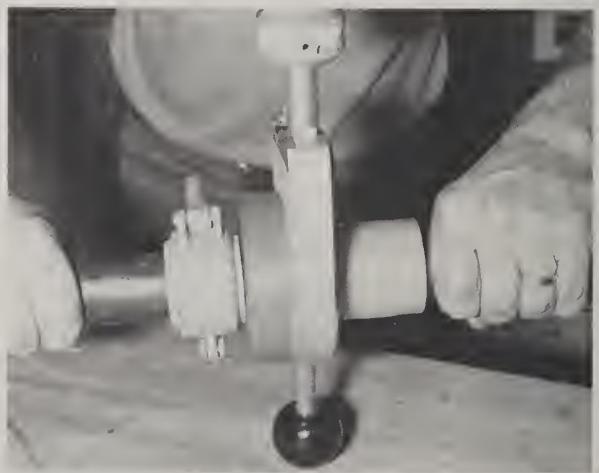
P&S Engineering Div.  
Ridge Tool Co.  
Box 1051  
Bartlesville, Okla. 74003  
(918) 336-5006

### For additional information refer to:

Karsky, R. 1978. Evaluating methods for joining plastic pipe. USDA Forest Serv. MEDC Project Record 7822 2210. 16 p. Equipment Development Center, Bldg. 1, Fort Missoula, Missoula, Mont.



*Butt-welding device for connecting sections of plastic pipe.*



*Socket fusion equipment for joining plastic pipe.*

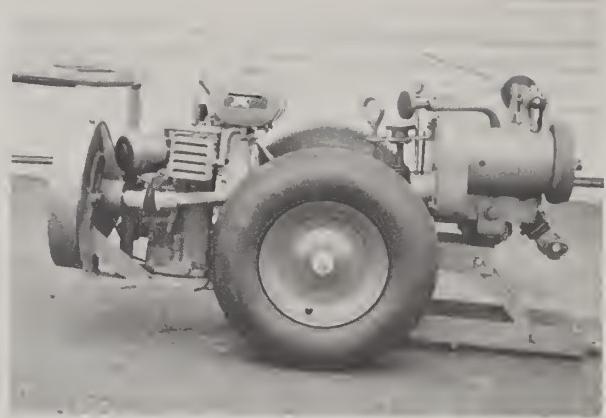
## Portable Disk Roller

### Function

Portable disk rollers sharpen and reshape disks from disk plows without disassembly of the disk plows.

### Description

The portable disk roller consists of two hardened steel rolls that are pressed against opposite sides of the disks. The rolls are mounted on heat-treated polished alloy shafts. They are chain-driven and powered by a gasoline engine or electric motor. The unit is mounted on a two-wheeled cart and is guided into position with a set of handlebars located above the engine. A special squeeze screw and ratchet assembly applies pressure to the disk. The machine is adjustable to obtain the correct concavity and sharpness.



*Portable disk roller.*

### Techniques

With the plow raised, the machine is positioned around a disk, adjusted, and engaged. The rolls spin, forming the disk to the desired shape and sharpness. An experienced operator can form and sharpen a small disk in less than 2 minutes.

### Capabilities

The disks are sharpened, toughened, and reshaped as in cold rolling. The process is completed without disassembling the plow.

### Limitations

The machine requires a skilled operator. The rolls must be reground occasionally because of wear.

#### Specifications

Roll diameter 6 in (15 cm)  
Weight 290 lb (122 kg)  
Power ratings 4 to 4.5 hp (3 to 3.3 kW) gasoline  
1.5 to 2 hp (1.1 to 1.5 kW) 110 to 220 V  
electric

#### Availability

Amy Manufacturing Co., Inc.  
Box 908  
West Highway 96  
Dighton, Kans. 67839  
(316) 397-5896

# Replacement Parts

## Function

Replacement parts rebuild equipment when the original parts break or wear out. Having replacement parts available can often prevent costly delays and perhaps insure the successful completion of the project.

## Description

The equipment parts that normally receive the most wear are those that make contact with the substrate. Heat-treated, or hard-surfaced disks, blades, teeth, shoes, shovels, points, knives, or sweeps are available as replacements. These and other parts, such as bearings or suspension components, are often needed for routine maintenance and help extend the useful life of the equipment.

## Techniques

Worn or broken parts are replaced for continued efficient operation. Defective parts should be discovered by routine maintenance or inspection before failure occurs. Heavy-duty replacement parts are sometimes installed in place of original equipment on new machines for superior performance or greater dependability.

## Capabilities

A nearby supply of spare parts will decrease down time and minimize loss of production caused by equipment malfunction.

## Limitations

Many, if not most, equipment parts are specialized for a specific make or type of equipment. Storage of many parts may not be feasible because of high costs or very low demand. Parts for very old equipment may no longer be manufactured or supplied.

### Specifications

Most replacement parts are equal to or exceed the quality of the original equipment.

### Availability

Replacement parts are available from most manufacturers and equipment dealers.

Parts and repair services for rangeland drills and brushland plows are available from:

USDI, Bureau of Land Management  
Vale District Office  
Box 700  
Vale, Oreg. 97918  
(503) 473-3144

## New VREW Developments

This section includes equipment being developed through Vegetative Rehabilitation and Equipment Workshop (VREW) projects. This equipment has not yet reached final development, but has undergone preliminary design, with prototypes either completed or under construction.

Most of the equipment is designed for revegetation of disturbed land in arid areas. These efforts reflect the difficulty of establishing suitable vegetative cover on areas with limited rainfall. The remaining equipment includes a device for controlling brush with hot air blasts and a portable backpack vacuum seed collector.

New projects are continually proposed to the VREW for consideration. Projects are selected and funded according to priorities determined by field demand. Many types of equipment developed under VREW sponsorship are now commercially manufactured and some are fairly common. It is the continuing goal of the VREW to test and evaluate available rangeland or revegetation equipment and to design and construct new equipment to fill specialized needs.

### Trailer-Mounted Blower Burner

#### Function

Trailer-mounted blower burners were developed by the USDA Forest Service, Missoula Equipment Development Center to control brush with hot air blasts. The blower burners can also be used for insect control, igniting controlled burns, and establishing firelines without soil disturbance.

#### Description

Trailer-mounted blower burners consist of a propane tank and two large blowers mounted on a trailer. The blowers each have a hydraulically powered fan and two propane burners inside a shroud. Fan speeds can be controlled by the operator. The blowers are mounted on brackets that allow 90° rotation.

The trailer has dual axles with large truck tires for high clearance.

#### Techniques

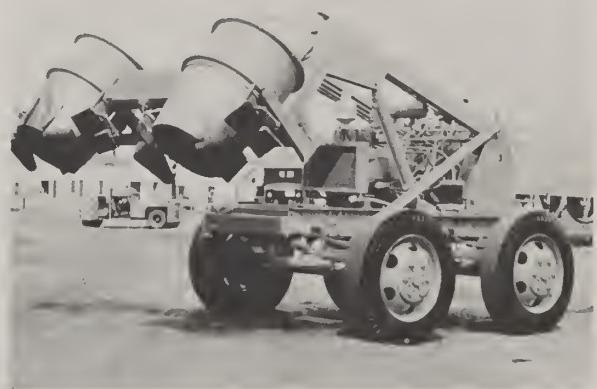
The trailer is towed over the area to be treated. The blowers are directed downward. The brush can be either ignited or controlled without ignition by hot air blasts. Moist brush is dried by the blast prior to ignition. Broad firelines can be burned after being treated with a herbicide or dessicant, while untreated vegetation on each side is still too green to carry a fire. Trailer-mounted blower burners have been used to control insects.

#### Capabilities

The trailer-mounted blower burner can control scattered and isolated brush with a minimum of personnel during periods of low fire danger. Firebreaks can be provided without disturbing the soil. The burners can operate up to 5 hours on a tank of fuel.

#### Limitations

Propane fuel is now expensive and in short supply. The trailer-mounted blower burner should be operated with extreme care, particularly when igniting brush, because of the potential hazard presented by a large amount of highly flammable material near the burners. The treated brush may require chemical or mechanical preparation.



*Trailer-mounted blower burner.*

## Specifications

Swath width 10 to 11 ft (3 to 3.4 m)  
Tank capacity 300 gal (1136 l)  
Operating pressure 120 lb/in<sup>2</sup> (827 kPa)  
Fan capacity 18,000 to 24,000 cu ft per min (5,486 to  
7,620 m<sup>3</sup>/min)  
Outlet velocity 35 to 45 mph (56 to 72 km/hr)  
Temperature 268 to 536° F (131 to 280° C)

## Availability

Information may be obtained from:

USDA, Forest Service  
Equipment Development Center  
Building 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

## Arid Land Seeder

### Function

The arid land seeder is designed to work with a root plow to rehabilitate brushy land in the arid southwest. The arid land seeder picks up brush, forms catch basins, prepares a seedbed, plants the seed, and deposits the brush over the seeded area.

### Description

The current arid land seeder is pulled behind a root plow. An improved design is being considered that operates on a self-propelled, rubber-tired chassis, such as a modified log skidder. The main feature of the arid land seeder is a brush conveyor system, consisting of two hay-rake pickups, a pickup conveyor, a main conveyor, and a dump gate. The arid land seeder also features a basin blade to create catch basins, four wide packing wheels to prepare the seedbed, and seed-box spreader with chain drags to plant the seed.

### Techniques

Before the arid land seeder is operated on an area, a root plow controls the brush in a separate operation. The arid land seeder gathers the brush onto the pickup conveyor that moves it to the main conveyor leading to the dump gate. Meanwhile a basin is scooped out of the ground and a seedbed is prepared by the basin blade and packing wheels. The seed is then broadcast in the basin and covered. Finally, the dump gate deposits the brush over the seeded area. The catch basins provide increased infiltration and percolation, making more moisture available to the seedlings. The brush covering provides shelter and shade, reducing erosion, soil temperature, and evaporation.

### Capabilities

The arid land seeder should successfully establish stands of grass on dry sandy soils. Sufficient moisture should be provided by the basins and brush cover for good stand development, even in areas with less than 7 in (17.7 cm) of rainfall per year.

### Limitations

The arid land seeder is not designed to treat steep, rough or rocky ground. The implement is designed to operate only on slopes up to 5 percent and at speeds of 1 to 2 miles (1.6 to 3.2 km) per hour.

### Specifications

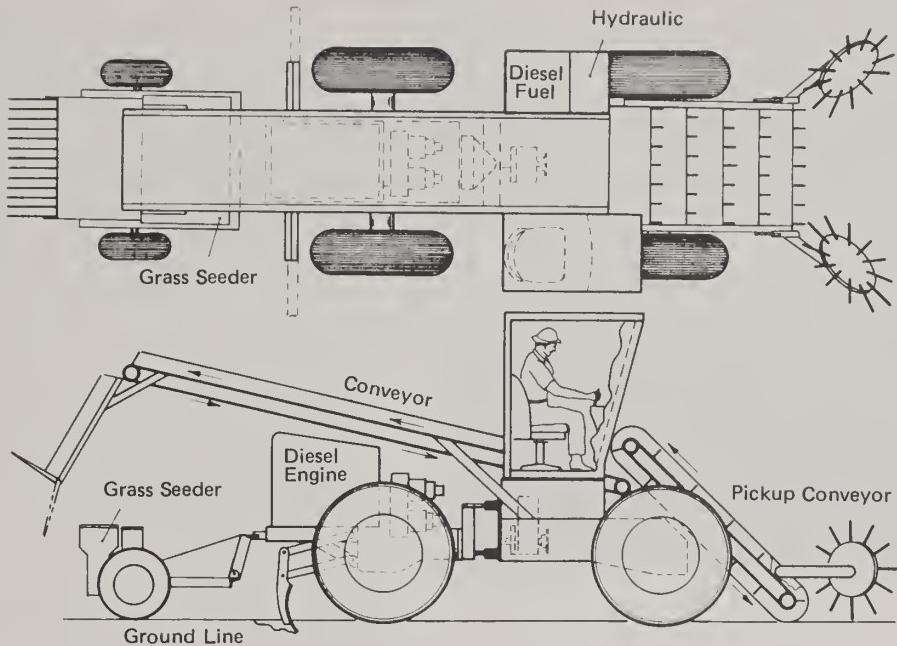
Specifications are not available because the arid land seeder is still under development.

### Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

USDA Science and Education Admin.  
Jornada Experimental Range  
Box 689  
Las Cruces, N.Mex. 88001  
(505) 646-4842  
FTS 572-0273



*Design concept for a self-propelled, rubber-tired arid land seeder.*

## Dryland Sodder

### Function

The dryland sodder strips the top layer of soil and vegetation from areas to be strip mined and places it, intact, over reclamation areas. The sodder can also transplant shrub root pads.

### Description

The dryland sodder is a modified front-end loader bucket. The side walls and back wall are vertical to minimize damage to shrubs and tree seedlings that are stripped along with the soil and sod. The wide, flat bottom of this bucket is lined with plastic to reduce friction. A conveyor system is being developed for the bottom of the dryland sodder to facilitate loading and unloading of the sod strips and to prevent excess soil separation during the transfer.

### Techniques

The soil layer is scooped into the sodder and transported to the reclamation area. It is removed by tilting and shaking the bucket while slowly moving the loader backward. The conveyor system will feature hydraulic control of the conveyor rollers, allowing the sod to be removed without tilting the bucket.

### Capabilities

The dryland sodder transfers native topsoil from the mine area to the reclamation area with its structure, profile, and vegetation intact. Reclamation is greatly enhanced because the soil horizons are not mixed, so soil evolution does not have to be repeated.

### Limitations

The tilting and shaking procedure may loosen the soil and break apart the sod. Deep cuts are necessary to adequately preserve the soil profile. Sod replacement is practical only on critical areas with high erosion potential.



*Dryland sodder.*

### Specifications

Width 14 ft (4.3 m)  
Length 8 ft (2.4 m)  
Depth to 12 in (30 cm)  
Power requirements (flywheel) 375 to 525 hp  
(80 to 391 kW)

### Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

## Dryland Tubeling Planter

### Function

The dryland tubeling planter has been designed by the USDA Forest Service, Equipment Development Center at Missoula, Montana, to automatically plant containerized stock on strip mine reclamation sites and other harsh, arid areas. It will handle 2- to 4-inch diameter by 24-inch length size class seedlings.

### Description

The dryland tubeling planter is a trailer unit that is towed behind a tractor. It features automatic leveling devices, an hydraulic auger with a scarifier, a rotating carousel mounted on a moveable carriage, and two packing spades.

### Techniques

The planting cycle is automatic and is controlled from the tractor. When the trailer is positioned, the platform is leveled with hydraulic cylinders. The auger digs a hole and is retracted, and the scarifier auger removes competition around the hole. The carousel containing the seedlings then rotates and the carriage moves forward on the platform, dropping a seedling into a

hole. The packing spades firm the soil around the seedling. The planting rate is estimated at more than one per minute.

### Capabilities

The dryland tubeling planter plants containerized shrubs or trees quickly and effectively. The leveling devices and high clearance enable operation on rough ground or moderate slopes, while insuring adequate placement.

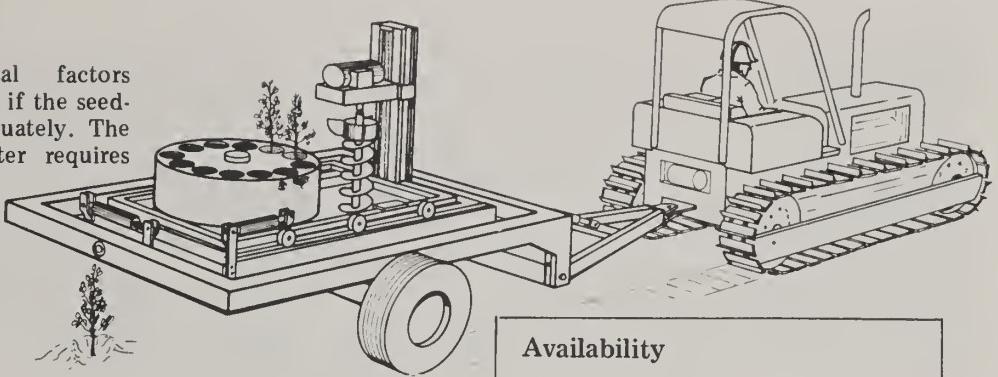
The containerized root system and auger holes allow sufficient moisture uptake and unrestricted root growth for better survival.

### Specifications

Carousel capacity 24 seedlings  
Auger diameter 3 to 5 in (7.6 to 12.7 cm)  
18 in (46 cm) scarifier  
Depth 24 to 30 in (61 to 76 cm)  
Power requirements (drawbar) 70 to 100 hp  
(52 to 75 kW)

## Limitations

Various environmental factors influence survival, even if the seedlings are planted adequately. The dryland tubeling planter requires containerized stock.



Dryland tubeling planter.

## Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

## Sprigger

### Function

The sprigger gathers bareroot, rhizomatous shrubs for transplanting. Mature native shrubs are removed from areas to be mined or surrounding areas and hand planted on selected reclamation sites.

### Description

The sprigger is a modified potato harvester. It consists of an undercutting blade and a pair of wide, inclined conveyors. The conveyors are long rods attached between two chains and spaced 1.5 in (3.8 cm) apart. A third conveyor across the top of the machine moves the harvested material to the side where it is dumped into a truck or piled in windrows. The sprigger is towed and powered by a tractor.

### Capabilities

The sprigger can quickly gather a large number of shrubs for transplanting. The soil is broken up and sifted through the machine, leaving the rhizomes intact.

### Limitations

The sprigger does not work well in heavy, clay soils. Large shrubs and plants with long taproots are usually destroyed by the operation. The rhizomatous shrubs require careful planting to assure survival and renewed growth, because many of their fibrous roots are removed or damaged during the process.

## Specifications

Width 5 ft (1.5 m)  
Depth to 12 in (30 cm)  
Power requirements (drawbar) 80 to 100 hp  
(60 to 75 kW)

## Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
Bldg. 1, Fort Missoula  
Missoula, Mont. 59801  
(406) 329-3157  
FTS 585-3157

### Techniques

After the shrubs are mowed, the sprigger is pulled through the stand cutting the roots well below the ground surface. The cutting action lifts the soil and shrubs onto the conveyors. The soil is shaken loose and falls through the spaces in the conveyors to the ground. The bareroot, rhizomatous shrubs, or sprigs, are gathered and carefully planted on the reclamation area.



*Sprigger.*

## Hand-Held Vacuum Seed Collectors

### Function

Hand-held vacuum seed collectors can selectively gather small quantities of seed from mixed stands. They are most useful when more seed is desired than can be easily collected by hand, but not enough is needed to warrant mechanized collection with larger equipment.

### Description

Small, self-contained backpack vacuums have been developed utilizing lightweight, commercial air brooms.

These units are powered with small gasoline engine compressors and feature 1½-in (3.3 cm) diameter air injection nozzles on long, corrugated hoses. The seed storage compartment is located above the engine.

Larger hand-held vacuum seed collectors are powered by big industrial air compressors. They have 3-to 6-in (7.6 to 15.2 cm) diameter injector nozzles for a much greater airflow and a more effective vacuum. Several of these units may be powered with a single compressor. The seed is collected in individual backpacks or rucksacks.

Attempts are being made to combine the effectiveness of large injector nozzles and hoses with the lightness and mobility of the air broom design.

### Techniques

Compressed air is fed into the nozzle and back through the system creating a vacuum. The operator directs the vacuum nozzle towards the seed to be collected. The suction removes the seed and transfers it to the storage container.

### Capabilities

Hand-held vacuum seed collectors permit a great deal of selectivity. Small quantities of a single type of seed can be collected from mixed stands. The hand-held systems may prove valuable for the collection of certain browse and forb seeds.

### Limitations

The performance of the small backpack unit is comparable to a household vacuum cleaner. The larger units require a separate air supply that restricts mobility and increases costs.

### Specifications

Air inlet diameter 1 to 6 in (2.5 to 15.2 cm)

Air inlet velocity:

7,000 ft/min (2,135 m/min) minimum  
9,000 to 10,500 ft/min (2,745 to 3,200 m/min)  
recommended

Storage capacity .5 to 2 cu ft (14 to 16 l)

Weight carried by the operator 24 to 35 lb  
(11 to 15 kg)

### Availability

Information may be obtained from:

USDA Forest Service  
Equipment Development Center  
444 East Bonita Ave.  
San Dimas, Calif. 91773  
(714) 599-1267 or (213) 332-6231  
FTS 793-8000

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# Appendix A

## Comparative Specifications<sup>1</sup> for Rubber-Tired Tractors

| Tractor Size                                  | Make            | Model          | Fuel Type     | Drawbar Power<br>hp (kW) | Rated Power<br>hp (kW) | Minimum Weight<br>lb (kg) | Standard PTO Speed<br>RPM | Hydraulic Capacity<br>gal/min (l/min) | Hitch Category |
|---|-----------------|----------------|---------------|--------------------------|------------------------|---------------------------|---------------------------|---------------------------------------|----------------|
| <b>Rear Wheel Drive Agricultural Tractors</b> |                 |                |               |                          |                        |                           |                           |                                       |                |
| W 20  | Allis Chalmers  | 5030           | Diesel        | 23 (17)                  | 26 (19)                | 2,280 (1,034)             | 540                       | 5.4 (20.4)                            | I              |
|   | Belarus         | 250            | Diesel        | 22 (16)                  | 25 (19)                | 3,750 (1,701)             | 540                       | 4.2 (15.9)                            | II             |
|   | John Deere      | 950            | Diesel        | 24 (18)                  | 27 (20)                | 2,558 (1,160)             | 540                       | 5.8 (22.0)                            | I              |
|   | Hefty           | G              | Gas           | 20 (15)                  | 24 (18)                | 2,100 (952)               | 540                       | 3.2 (12.1)                            | I              |
|   |                 | G              | Diesel        | 24 (18)                  | 27 (20)                | 2,100 (952)               | 540                       | 3.2 (12.1)                            | I              |
|   |                 | Hi-G           | Gas           | 20 (15)                  | 24 (18)                | 3,580 (1,624)             | 540                       | 3.2 (12.1)                            | N/A            |
|   |                 | Hi-G           | Diesel        | 24 (18)                  | 27 (20)                | 3,580 (1,624)             | 540                       | 3.2 (12.1)                            | N/A            |
|   | Hinomoto        | E 280          | Diesel        | 22 (16)                  | 28 (21)                | 2,233 (1,013)             | 540 or 1,000              | 5.4 (20.4)                            | I              |
|   | Intl. Harvester | 140            | Gas           | 21 (16)                  | 24 (18)                | 2,722 (1,235)             | 540                       | 5.0 (18.9)                            | N/A            |
|   |                 | 140            | Gas           | 21 (16)                  | 24 (18)                | 3,067 (1,391)             | 540                       | 5.0 (18.9)                            | N/A            |
|   |                 | Hi-Clear 284   | Gas           | 20 (15)                  | 24 (18)                | 2,050 (930)               | 540 or 1,000              | 6.0 (22.7)                            | I              |
|   | Kubota          | L245HC         | Diesel        | 21 (16)                  | 25 (19)                | 2,345 (1,064)             | 540 or 1,000              | 3.5 (13.3)                            | I              |
|   |                 | L245DT*        | Diesel        | 21 (16)                  | 25 (19)                | 1,850 (8,391)             | 540 or 1,000              | 3.7 (14.0)                            | I              |
|   |                 | L285           | Diesel        | 23 (17)                  | 27 (20)                | 2,330 (1,057)             | 540 or 1,000              | 5.0 (18.9)                            | I              |
|   | Massey Ferguson | MF 220         | Diesel        | 22 (16)                  | 26 (19)                | 2,390 (1,084)             | 540                       | 5.4 (20.4)                            | I              |
|   |                 | MF 220-4*      | Diesel        | 22 (16)                  | 26 (19)                | 2,700 (1,225)             | 540                       | 5.4 (20.4)                            | I              |
|   | Satoh           | Bull*          | Diesel        | 21 (16)                  | 25 (19)                | 1,938 (879)               | 540 or 1,000              | 4.7 (17.8)                            | I              |
| W 25  | Deutz           | D3006          | Diesel        | 28 (21)                  | 32 (24)                | 3,980 (1,805)             | 540                       | 7.2 (27.3)                            | I              |
|   | Kubota          | L295           | Diesel        | 26 (19)                  | 30 (22)                | 2,304 (1,045)             | 540 or 1,000              | 7.3 (27.6)                            | I              |
|   |                 | L295DT*        | Diesel        | 26 (19)                  | 30 (22)                | 2,600 (1,179)             | 540 or 1,000              | 5.6 (21.2)                            | I              |
|   |                 | L345           | Diesel        | 29 (22)                  | 34 (25)                | 2,575 (1,168)             | 540 or 1,000              | 6.7 (25.4)                            | I              |
|   |                 | L345DT*        | Diesel        | 29 (22)                  | 34 (25)                | 3,475 (1,576)             | 540 or 1,000              | 6.7 (25.4)                            | I              |
|   | Lamborghini     | R-235*         | Diesel        | 26 (19)                  | 32 (24)                | 3,120 (1,415)             | 540                       | 2.9 (11.0)                            | I              |
|   | Massey Ferguson | MF 230G        | Gas           | 30 (22)                  | 34 (25)                | 3,600 (1,633)             | 540                       | 4.0 (15.1)                            | I              |
|   |                 | MF 230D        | Diesel        | 30 (22)                  | 35 (26)                | 3,500 (1,586)             | 540                       | 4.0 (15.1)                            | I              |
|   | Same'           | Delfino 35     | Diesel        | 26 (19)                  | 32 (24)                | 2,910 (1,320)             | 540                       | 3.2 (12.1)                            | I              |
|   |                 | Delfino 354RM* | Diesel        | 26 (19)                  | 32 (24)                | 3,240 (1,470)             | 540                       | 3.2 (12.1)                            | I              |
|   | Satoh           | Stallion*      | Diesel        | 28 (21)                  | 33 (25)                | 2,863 (1,299)             | 540 or 1,000              | 9.2 (34.8)                            | I              |
|   | Yanmar          | YM330*         | Diesel        | 28 (21)                  | 33 (25)                | 2,552 (1,158)             | 540 or 1,000              | 5.8 (22.0)                            | I              |
| W 30  | John Deere      | 2040 Utility   | Diesel        | 34 (25)                  | 41 (31)                | 4,060 (1,842)             | 540                       | 12.0 (45.4)                           | I              |
|   | Ford            | 2600           | Gas or Diesel | 30 (22)                  | 32 (24)                | 3,475 (1,576)             | 540                       | 8.5 (32.2)                            | I              |
|   |                 | 3600           | Gas or Diesel | 35 (26)                  | 40 (30)                | 3,665 (1,662)             | 540                       | 8.5 (32.2)                            | I              |
|   | Intl. Harvester | 384            | Diesel        | 31 (23)                  | 36 (27)                | 3,860 (1,751)             | 540                       | 9.0 (34.1)                            | I              |
|   | Long            | 360            | Diesel        | 30 (22)                  | 32 (24)                | 3,750 (1,701)             | 540                       | 5.8 (22.0)                            | I or II        |
|   | Massey Ferguson | 245G           | Gas           | 35 (26)                  | 41 (31)                | 3,750 (1,701)             | 540                       | 4.5 (17.0)                            | I              |
|   | McKee/Elbro     | 350            | Diesel        | 32 (24)                  | 45 (33)                | 4,300 (3,207)             | 540                       | 5.3 (20.1)                            | II             |
|   | Same'           | Aurora 45      | Diesel        | 35 (26)                  | 42 (31)                | 3,420 (1,551)             | 540                       | 4.0 (15.1)                            | I              |
|   | Steyr           | 548            | Diesel        | 34 (25)                  | 50 (37)                | 4,320 (1,960)             | 540 or 1,000              | 6.0 (22.7)                            | I or II        |
|   |                 | 548A*          | Diesel        | 34 (25)                  | 50 (37)                | 4,920 (2,232)             | 540 or 1,000              | 6.0 (22.7)                            | I or II        |
| W 35  | Allis Chalmers  | 5040           | Diesel        | 35 (26)                  | 40 (30)                | 3,850 (1,746)             | 540                       | 6.2 (23.5)                            | I or II        |
|   | J. I. Case      | 885            | Diesel        | 37 (28)                  | 43 (32)                | 4,290 (1,946)             | 540 or 1,000              | 7.3 (27.6)                            | I              |
|   | Deutz           | D4506          | Diesel        | 37 (28)                  | 43 (32)                | 4,170 (1,891)             | 540                       | 7.3 (27.6)                            | I              |
|   |                 | D4506A*        | Diesel        | 37 (28)                  | 43 (32)                | 5,080 (2,304)             | 540                       | 7.3 (27.6)                            | I              |
|   | Fiat            | 420            | Diesel        | 37 (28)                  | 43 (32)                | 3,630 (1,650)             | 540                       | 4.3 (16.3)                            | I              |
|   |                 | 420DT*         | Diesel        | 37 (28)                  | 40 (30)                | 4,070 (1,846)             | 540                       | 4.3 (16.3)                            | I              |
|   |                 | 480            | Diesel        | 40 (30)                  | 47 (35)                | 3,790 (1,719)             | 540                       | 5.0 (18.9)                            | I or II        |
|   |                 | 480DT*         | Diesel        | 40 (30)                  | 47 (35)                | 4,570 (2,073)             | 540                       | 5.0 (18.9)                            | I or II        |
|   |                 | 500            | Diesel        | 40 (30)                  | 47 (35)                | 4,030 (1,828)             | 540                       | 5.0 (18.9)                            | I or II        |
|   |                 | 500DT*         | Diesel        | 40 (30)                  | 47 (35)                | 4,800 (2,177)             | 540                       | 5.0 (18.9)                            | I or II        |
|   | Intl. Harvester | 484            | Diesel        | 36 (27)                  | 42 (31)                | 4,660 (2,114)             | 540                       | 10.5 (39.8)                           | I              |
|   | Lamborghini     | R-503*         | Diesel        | 38 (28)                  | 44 (33)                | 3,970 (1,801)             | 540 or 1,000              | 5.8 (22.0)                            | I              |
|   | British Leyland | 245            | Diesel        | 35 (26)                  | 40 (30)                | 4,655 (2,112)             | 540                       | 7.8 (29.5)                            | I or II        |
|   | Long            | 460            | Diesel        | 38 (28)                  | 42 (31)                | 3,850 (1,746)             | 540                       | 5.8 (22.0)                            | I or II        |
|   |                 | 460V           | Diesel        | 38 (28)                  | 42 (31)                | 3,550 (1,610)             | 540                       | 5.8 (22.0)                            | I or II        |
|   |                 | 460SD          | Diesel        | 38 (28)                  | 42 (31)                | 4,410 (2,000)             | 540                       | 5.8 (22.0)                            | I or II        |
|   |                 | 460DT*         | Diesel        | 38 (28)                  | 42 (31)                | 4,420 (2,005)             | 540                       | 5.8 (22.0)                            | I or II        |
|   | Massey Ferguson | MF 245D        | Diesel        | 36 (27)                  | 42 (31)                | 3,650 (1,656)             | 540                       | 4.5 (17.0)                            | I              |
|   | Same'           | Falcon 2RM     | Diesel        | 39 (29)                  | 47 (35)                | 3,720 (1,687)             | 540                       | 3.8 (14.4)                            | I              |
|   |                 | Falcon 4RM*    | Diesel        | 39 (29)                  | 47 (35)                | 4,200 (1,905)             | 540                       | 3.8 (14.4)                            | I              |

<sup>1/</sup> Most specifications were obtained from: Intertec Publishing Company 1979. 63rd annual redbook edition. Implement and Tractor 94(3):A1-A244.

## Comparative Specifications for Rubber-Tired Tractors

| Tractor Size | Make            | Model             | Fuel Type     | Drawbar Power |      | Rated Power |      | Minimum Weight |         | Standard PTO Speed |      | Hydraulic Capacity gal/min (l/min) | Hitch Category |
|--------------|-----------------|-------------------|---------------|---------------|------|-------------|------|----------------|---------|--------------------|------|------------------------------------|----------------|
|              |                 |                   |               | hp            | (kW) | hp          | (kW) | lb             | (kg)    | RPM                |      |                                    |                |
| W40          | Allis Chalmers  | 5050*             | Diesel        | 43            | (32) | 51          | (38) | 4,150          | (1,882) | 540                | 6.5  | (24.6)                             | I or II        |
|              | John Deere      | 2240 Utility      | Diesel        | 41            | (31) | 50          | (37) | 4,255          | (1,930) | 540                | 12.0 | (45.4)                             | I or II        |
|              |                 | 2240 Orchard      | Diesel        | 41            | (31) | 50          | (37) | 4,050          | (1,837) | 540                | 12.0 | (45.4)                             | I or II        |
|              |                 | 2240 Vineyard     | Diesel        | 41            | (31) | 50          | (37) | 4,200          | (1,905) | 540                | 12.0 | (45.4)                             | I or II        |
|              | Fiat            | 540S              | Diesel        | 42            | (31) | 49          | (37) | 4,120          | (1,869) | 540                | 6.2  | (23.5)                             | I or II        |
|              |                 | 540DTS*           | Diesel        | 42            | (31) | 49          | (37) | 4,850          | (2,200) | 540                | 6.2  | (23.5)                             | I or II        |
|              | Ford            | 4100              | Diesel        | 41            | (31) | 45          | (34) | 4,340          | (1,969) | 540                | 8.5  | (32.2)                             | I or II        |
|              | Intl. Harvester | 584 Utility       | Diesel        | 44            | (33) | 52          | (39) | 4,843          | (2,197) | 540                | 9.5  | (36.0)                             | II             |
|              |                 | 584 Row Crop      | Diesel        | 44            | (33) | 52          | (39) | 5,360          | (2,431) | 540                | 9.5  | (36.0)                             | II             |
|              | Kubota          | M4000             | Diesel        | 40            | (30) | 48          | (36) | 4,125          | (1,871) | 540 or 1,000       | 7.3  | (27.6)                             | I              |
|              |                 | M4000DT*          | Diesel        | 40            | (30) | 48          | (36) | 4,785          | (2,170) | 540 or 1,000       | 7.3  | (27.6)                             | I              |
|              | Long            | 510               | Diesel        | 43            | (32) | 49          | (37) | 4,900          | (1,769) | 540                | 6.3  | (23.9)                             | I or II        |
|              |                 | 510DT*            | Diesel        | 43            | (32) | 49          | (37) | 4,470          | (2,028) | 540                | 6.3  | (23.9)                             | I or II        |
|              | Massey Ferguson | MF 2550           | Diesel        | 43            | (32) | 52          | (39) | 4,710          | (2,136) | 540                | 10.0 | (37.9)                             | I or II        |
|              | Same*           | Minitauro 60      | Diesel        | 43            | (32) | 52          | (39) | 3,930          | (1,783) | 540                | 3.8  | (14.9)                             | II             |
|              |                 | Minitauro 60 4RM* | Diesel        | 43            | (32) | 52          | (39) | 4,480          | (2,032) | 540                | 3.8  | (14.4)                             | II             |
|              | Steyr           | 658               | Diesel        | 43            | (32) | 56          | (42) | 5,192          | (2,355) | 540 or 1,000       | 9.0  | (34.1)                             | I or II        |
|              |                 | 658A*             | Diesel        | 43            | (32) | 56          | (42) | 5,600          | (2,540) | 540 or 1,000       | 9.0  | (34.1)                             | I or II        |
|              | White           | 2-50*             | Diesel        | 42            | (31) | 47          | (35) | 3,970          | (1,801) | 540                | 6.0  | (22.7)                             | I or II        |
| W45          | Belarus         | 400               | Diesel        | 45            | (34) | 53          | (40) | 5,027          | (2,280) | 540                | 11.8 | (44.7)                             | II             |
|              |                 | 420*              | Diesel        | 45            | (34) | 53          | (40) | 5,530          | (2,508) | 540                | 11.8 | (44.7)                             | II             |
|              | J. I. Case      | 990               | Diesel        | 46            | (34) | 54          | (40) | 4,780          | (2,168) | 540 or 1,000       | 7.3  | (27.6)                             | I or II        |
|              | Fiat            | 580               | Diesel        | 45            | (34) | 53          | (40) | 4,730          | (2,145) | 540                | 6.2  | (23.5)                             | I or II        |
|              |                 | 580DT             | Diesel        | 45            | (34) | 53          | (40) | 5,170          | (2,345) | 540                | 6.5  | (24.6)                             | I or II        |
|              | Ford            | 4600              | Gas or Diesel | 46            | (34) | 52          | (39) | 4,480          | (2,032) | 540                | 8.5  | (32.2)                             | I or II        |
|              |                 | 4600SU            | Gas or Diesel | 46            | (34) | 52          | (39) | 4,360          | (1,978) | 540                | 8.5  | (32.2)                             | I or II        |
|              | Intl. Harvester | Hydro 84 Utility  | Diesel        | 48            | (36) | 56          | (42) | 5,155          | (2,338) | 540                | 10.5 | (39.8)                             | II             |
|              |                 | Hydro 84 Row Crop | Diesel        | 48            | (36) | 56          | (42) | 5,539          | (2,512) | 540                | 10.5 | (39.8)                             | II             |
|              | Kubota          | M4500             | Diesel        | 47            | (35) | 55          | (41) | 4,220          | (1,914) | 540                | 7.3  | (27.6)                             | I              |
|              |                 | M4500DT*          | Diesel        | 47            | (35) | 55          | (41) | 4,760          | (2,159) | 540                | 7.3  | (27.6)                             | I              |
|              | Lamborghini     | R-603*            | Diesel        | 45            | (34) | 53          | (40) | 4,340          | (1,969) | 540 or 1,000       | 5.8  | (22.0)                             | II             |
|              | British Leyland | 262               | Diesel        | 45            | (34) | 53          | (40) | 5,365          | (2,434) | 540                | 7.8  | (29.5)                             | I or II        |
|              | Long            | 560DTE*           | Diesel        | 48            | (36) | 55          | (41) | 5,450          | (2,472) | 540                | 5.8  | (22.0)                             | I or II        |
|              | McKee/Elbro     | 460               | Diesel        | 45            | (34) | 57          | (43) | 4,500          | (2,041) | 540                | 5.3  | (20.1)                             | II             |
|              | Steyr           | 768               | Diesel        | 49            | (37) | 65          | (48) | 5,181          | (2,350) | 540 or 1,000       | 9.0  | (34.1)                             | I or II        |
|              |                 | 768A*             | Diesel        | 49            | (37) | 65          | (48) | 5,550          | (2,517) | 540 or 1,000       | 9.0  | (34.1)                             | I or II        |
| W50          | J. I. Case      | 995*              | Diesel        | 50            | (37) | 59          | (44) | 4,780          | (2,168) | 540 or 1,000       | 7.3  | (27.6)                             | I or II        |
|              |                 | 1210 Power Shift  | Diesel        | 54            | (40) | 65          | (48) | 6,100          | (2,767) | 540 or 1,000       | 15.5 | (58.7)                             | II             |
|              | John Deere      | 2440 Utility      | Diesel        | 52            | (39) | 61          | (45) | 4,800          | (2,177) | 540 or 1,000       | 12.0 | (45.4)                             | II             |
|              | Deutz           | D6206             | Diesel        | 52            | (39) | 60          | (45) | 4,660          | (2,114) | 540                | 7.5  | (28.4)                             | I or II        |
|              |                 | D6206A*           | Diesel        | 52            | (39) | 60          | (45) | 5,356          | (2,429) | 540                | 7.5  | (28.4)                             | II             |
|              | Fiat            | 640               | Diesel        | 53            | (40) | 62          | (46) | 4,700          | (2,132) | 540                | 5.8  | (22.0)                             | I or II        |
|              |                 | 640DT*            | Diesel        | 53            | (40) | 62          | (46) | 5,360          | (2,431) | 540                | 5.8  | (22.0)                             | I or II        |
|              |                 | 680               | Diesel        | 54            | (40) | 64          | (48) | 5,170          | (2,345) | 540 or 1,000       | 6.8  | (25.7)                             | II             |
|              |                 | 680DT*            | Diesel        | 54            | (40) | 64          | (48) | 5,610          | (2,545) | 540 or 1,000       | 6.8  | (25.7)                             | II             |
|              | Ford            | 5600              | Diesel        | 52            | (39) | 60          | (45) | 5,475          | (2,483) | 540 or 1,000       | 9.7  | (36.7)                             | I or II        |
|              | Intl. Harvester | 684 Utility       | Diesel        | 53            | (40) | 62          | (46) | 5,210          | (2,363) | 540                | 10.5 | (39.8)                             | II             |
|              |                 | 684 Row Crop      | Diesel        | 53            | (40) | 62          | (46) | 5,075          | (2,302) | 540                | 10.5 | (39.8)                             | II             |
|              |                 | Hydro 86          | Diesel        | 54            | (40) | 69          | (51) | 7,710          | (3,497) | 540                | 15.0 | (56.8)                             | II             |
|              | British Leyland | 272               | Diesel        | 53            | (40) | 62          | (46) | 5,600          | (2,540) | 540                | 7.8  | (29.5)                             | I or II        |
|              | Long            | 610               | Diesel        | 55            | (41) | 64          | (48) | 4,560          | (2,068) | 540                | 6.3  | (23.9)                             | I or II        |
|              |                 | 610DT*            | Diesel        | 55            | (41) | 64          | (48) | 4,800          | (2,177) | 540                | 6.3  | (23.9)                             | I or II        |
|              | Massey Ferguson | MF 265D           | Diesel        | 52            | (39) | 61          | (45) | 4,930          | (2,236) | 540                | 10.0 | (37.9)                             | II             |
|              | McKee/Elbro     | 470               | Diesel        | 53            | (40) | 67          | (50) | 5,182          | (2,351) | 540                | 6.6  | (25.0)                             | II             |
|              | Same*           | Corsaro70         | Diesel        | 51            | (38) | 62          | (46) | 5,650          | (2,563) | 540                | 6.4  | (24.2)                             | II             |
|              |                 | Corsaro704RM*     | Diesel        | 51            | (38) | 62          | (46) | 5,800          | (2,631) | 540                | 6.4  | (24.2)                             | II             |
|              | White           | 2-60*             | Diesel        | 55            | (41) | 63          | (47) | 4,360          | (1,978) | 540                | 5.8  | (22.0)                             | I or II        |

## Comparative Specifications for Rubber-Tired Tractors

| Tractor Size |                 | Fuel Type           | Drawbar Power |         | Rated Power |                | Minimum Weight |                 | Standard PTO Speed |  | Hydraulic Capacity |  | Hitch Category |
|--------------|-----------------|---------------------|---------------|---------|-------------|----------------|----------------|-----------------|--------------------|--|--------------------|--|----------------|
| Make         | Model           |                     | hp (kW)       | hp (kW) | lb (kg)     | (kg)           | RPM            | gal/min (l/min) |                    |  |                    |  |                |
| W55          | Allis Chalmers  | 175D                | Diesel        | 55 (41) | 63 (47)     | 4,992 (2,264)  |                | 540             | 11.0 (41.6)        |  |                    |  | II             |
|              | Belarus         | 500                 | Diesel        | 55 (41) | 63 (47)     | 6,060 (2,749)  |                | 540             | 11.8 (44.7)        |  |                    |  | II             |
|              | J. I. Case      | 1210* Syncromesh    | Diesel        | 57 (43) | 66 (49)     | 5,900 (2,676)  |                | 540 or 1,000    | 15.5 (58.7)        |  |                    |  | II             |
|              | John Deere      | 2640 Utility        | Diesel        | 58 (43) | 70 (52)     | 5,400 (2,449)  |                | 540 or 1,000    | 12.0 (45.4)        |  |                    |  | II             |
|              | Intl. Harvester | 784 Utility         | Diesel        | 55 (41) | 65 (48)     | 5,395 (2,447)  |                | 540             | 10.5 (39.8)        |  |                    |  | II             |
|              |                 | 784 Row Crop        | Diesel        | 55 (41) | 65 (48)     | 5,937 (2,693)  |                | 540             | 10.5 (39.8)        |  |                    |  | II             |
|              |                 | 686                 | Diesel        | 58 (43) | 66 (49)     | 7,500 (3,402)  |                | 540             | 15.0 (56.8)        |  |                    |  | II             |
|              | Lamborghini     | R-704*              | Diesel        | 58 (43) | 68 (51)     | 5,960 (2,703)  |                | 540 or 1,000    | 6.3 (23.9)         |  |                    |  | II             |
| W60          | White           | 2-70*               | Gas or Diesel | 60 (45) | 71 (53)     | 7,500 (3,402)  |                | 540 or 1,000    | 14.6 (55.3)        |  |                    |  | I or II        |
|              | Belarus         | 520*                | Diesel        | 60 (45) | 63 (47)     | 6,500 (2,948)  |                | 540             | 11.8 (44.6)        |  |                    |  | II             |
|              | Deutz           | D6806               | Diesel        | 62 (46) | 68 (51)     | 5,700 (2,585)  |                | 540 or 1,000    | 9.2 (34.8)         |  |                    |  | II             |
|              |                 | D6806A*             | Diesel        | 62 (46) | 68 (51)     | 6,700 (3,039)  |                | 540 or 1,000    | 9.2 (34.8)         |  |                    |  | II             |
|              | Fiat            | 780                 | Diesel        | 61 (45) | 72 (54)     | 5,520 (2,504)  |                | 540 or 1,000    | 6.8 (25.7)         |  |                    |  | II             |
|              |                 | 780DT*              | Diesel        | 61 (45) | 72 (54)     | 6,180 (2,803)  |                | 540 or 1,000    | 6.8 (25.7)         |  |                    |  | II             |
|              | Ford            | 6600                | Diesel        | 61 (45) | 71 (53)     | 5,475 (2,483)  |                | 540 or 1,000    | 9.7 (36.7)         |  |                    |  | I or II        |
|              |                 | 6700                | Diesel        | 60 (45) | 71 (53)     | 6,900 (3,130)  |                | 540 or 1,000    | 9.7 (36.7)         |  |                    |  | I or II        |
| W65          | British Leyland | 285                 | Diesel        | 64 (48) | 74 (55)     | 8,000 (3,628)  |                | 540 or 1,000    | 10.9 (41.3)        |  |                    |  | II             |
|              |                 | 485*                | Diesel        | 64 (48) | 74 (55)     | 10,800 (4,899) |                | 540 or 1,000    | 10.9 (41.3)        |  |                    |  | II             |
|              | Long            | 910                 | Diesel        | 63 (47) | 73 (54)     | 7,750 (3,515)  |                | 540 or 1,000    | 10.0 (37.9)        |  |                    |  | II             |
|              |                 | 910DT*              | Diesel        | 63 (47) | 73 (54)     | 8,740 (3,964)  |                | 540 or 1,000    | 15.0 (56.8)        |  |                    |  | II             |
|              | Massey Ferguson | MF275D              | Diesel        | 60 (45) | 67 (50)     | 4,940 (2,240)  |                | 540             | 10.0 (37.9)        |  |                    |  | II             |
|              | McKee/Elbro     | 480                 | Diesel        | 61 (45) | 73 (54)     | 5,336 (2,420)  |                | 540             | 6.6 (25.0)         |  |                    |  | II             |
|              | Same'           | Saturno 80          | Diesel        | 60 (45) | 73 (54)     | 5,650 (2,563)  |                | 540             | 6.4 (24.2)         |  |                    |  | II             |
|              |                 | Saturno 840RM*      | Diesel        | 60 (45) | 73 (54)     | 6,200 (2,812)  |                | 540             | 6.4 (24.2)         |  |                    |  | II             |
| W70          | Allis Chalmers  | 1850                | Diesel        | 65 (48) | 75 (56)     | 6,200 (2,812)  |                | 540             | 11.0 (41.6)        |  |                    |  | II             |
|              | Belarus         | 800                 | Diesel        | 66 (48) | 75 (56)     | 6,700 (3,039)  |                | 540 or 1,000    | 11.8 (44.7)        |  |                    |  | II             |
|              | J. I. Case      | 1410 Power Shift    | Diesel        | 68 (51) | 81 (60)     | 7,310 (3,316)  |                | 540 or 1,000    | 15.5 (58.7)        |  |                    |  | II             |
|              |                 | 1410 Syncromesh     | Diesel        | 69 (51) | 81 (60)     | 7,150 (3,243)  |                | 540 or 1,000    | 15.5 (58.7)        |  |                    |  | II             |
|              | John Deere      | 2480 Util. Row Crop | Diesel        | 69 (51) | 81 (60)     | 8,500 (3,856)  |                | 540 or 1,000    | 18.0 (68.1)        |  |                    |  | II             |
|              | Ford            | 7600                | Diesel        | 68 (51) | 85 (63)     | 5,580 (2,531)  |                | 540 or 1,000    | 9.7 (36.7)         |  |                    |  | I or II        |
|              | Lamborghini     | R-804*              | Diesel        | 66 (49) | 77 (57)     | 6,060 (2,749)  |                | 540 or 1,000    | 6.3 (23.9)         |  |                    |  | II             |
|              | Same'           | Panter 2RM          | Diesel        | 66 (49) | 80 (60)     | 6,390 (2,898)  |                | 540 or 1,000    | 8.0 (30.3)         |  |                    |  | II             |
| W75          |                 | Panter 4RM*         | Diesel        | 66 (49) | 80 (60)     | 6,940 (3,148)  |                | 540 or 1,000    | 8.0 (30.3)         |  |                    |  | II             |
|              | Steyr           | 988                 | Diesel        | 67 (50) | 85 (63)     | 7,165 (3,250)  |                | 540 or 1,000    | 9.8 (37.1)         |  |                    |  | II             |
|              |                 | 988A*               | Diesel        | 67 (50) | 85 (63)     | 7,890 (3,579)  |                | 540 or 1,000    | 9.8 (37.1)         |  |                    |  | II             |
|              |                 | 8100                | Diesel        | 66 (49) | 85 (63)     | 8,565 (3,885)  |                | 540 or 1,000    | 9.2 (34.8)         |  |                    |  | II             |
|              |                 | 8100A*              | Diesel        | 66 (49) | 85 (63)     | 9,280 (4,209)  |                | 540 or 1,000    | 9.2 (34.8)         |  |                    |  | II             |
|              | White           | 700*                | Diesel        | 66 (49) | 78 (58)     | 5,380 (2,440)  |                | 540 or 1,000    | 7.0 (26.5)         |  |                    |  | II             |
|              | Belarus         | 820*                | Diesel        | 70 (52) | 75 (56)     | 7,150 (3,243)  |                | 540 or 1,000    | 11.8 (44.6)        |  |                    |  | II             |
|              | John Deere      | 4040*               | Diesel        | 74 (55) | 90 (67)     | 11,354 (5,150) |                | 540 or 1,000    | 20.0 (75.7)        |  |                    |  | I or II        |
| W70          | Deutz           | D8006               | Diesel        | 75 (56) | 86 (64)     | 6,834 (3,100)  |                | 540 or 1,000    | 9.5 (36.0)         |  |                    |  | II             |
|              |                 | D8006A*             | Diesel        | 75 (56) | 86 (64)     | 7,590 (3,443)  |                | 540 or 1,000    | 9.5 (36.0)         |  |                    |  | II             |
|              |                 | DX90                | Diesel        | 71 (53) | 84 (63)     | 9,260 (4,200)  |                | 540 or 1,000    | 14.7 (55.7)        |  |                    |  | II             |
|              |                 | DX90A*              | Diesel        | 71 (53) | 84 (63)     | 10,500 (4,763) |                | 540 or 1,000    | 14.7 (55.7)        |  |                    |  | II             |
|              | Fiat            | 880                 | Diesel        | 70 (52) | 82 (61)     | 6,200 (2,812)  |                | 540 or 1,000    | 7.0 (26.5)         |  |                    |  | II             |
|              |                 | 880DT*              | Diesel        | 70 (52) | 82 (61)     | 6,850 (3,107)  |                | 540 or 1,000    | 7.0 (26.5)         |  |                    |  | II             |
|              | Ford            | 7700                | Diesel        | 72 (54) | 84 (63)     | 7,100 (3,221)  |                | 540 or 1,000    | 9.7 (36.7)         |  |                    |  | I or II        |
|              | Lamborghini     | R-904*              | Diesel        | 74 (55) | 86 (64)     | 6,830 (3,098)  |                | 540 or 1,000    | 6.3 (23.9)         |  |                    |  | II             |
| W75          | Long            | 1110                | Diesel        | 74 (55) | 92 (69)     | 8,250 (3,742)  |                | 540 or 1,000    | 10.0 (37.9)        |  |                    |  | II             |
|              | Massey Ferguson | MF285               | Diesel        | 70 (52) | 82 (61)     | 6,005 (2,724)  |                | 540 or 1,000    | 10.0 (37.9)        |  |                    |  | II             |
|              |                 | MF1085              | Diesel        | 71 (53) | 82 (61)     | 7,400 (3,357)  |                | 540 or 1,000    | 10.0 (37.9)        |  |                    |  | II             |
|              | White           | 2-85*               | Diesel        | 72 (54) | 86 (64)     | 11,350 (5,148) |                | 540 or 1,000    | 20.0 (75.7)        |  |                    |  | II or III      |
|              | John Deere      | 4040 Row Crop       | Diesel        | 78 (58) | 91 (68)     | 9,630 (4,369)  |                | 540 or 1,000    | 20.0 (75.7)        |  |                    |  | II or I        |
|              | Fiat            | 850S                | Diesel        | 77 (57) | 90 (67)     | 7,040 (3,193)  |                | 540 or 1,000    | 10.9 (41.3)        |  |                    |  | II             |
|              |                 | 850DTS*             | Diesel        | 77 (57) | 90 (67)     | 8,200 (3,719)  |                | 540 or 1,000    | 10.9 (41.3)        |  |                    |  | II             |
|              | Intl. Harvester | 886                 | Diesel        | 76 (57) | 86 (64)     | 10,475 (4,751) |                | 540 or 1,000    | 13.0 (49.2)        |  |                    |  | II             |
| W75          | British Leyland | 2100                | Diesel        | 76 (57) | 88 (66)     | 8,470 (3,842)  |                | 540 or 1,000    | 10.9 (41.3)        |  |                    |  | II             |
|              |                 | 4100*               | Diesel        | 77 (57) | 89 (66)     | 10,800 (4,899) |                | 540 or 1,000    | 11.1 (42.0)        |  |                    |  | II             |

## Comparative Specifications for Rubber-Tired Tractors

| Tractor Size    | Make            | Model                               | Fuel Type | Drawbar Power |       | Rated Power |       | Minimum Weight |         | Standard PTO Speed RPM | Hydraulic Capacity gal/min (l/min) | Hitch Category |
|-----------------|-----------------|-------------------------------------|-----------|---------------|-------|-------------|-------|----------------|---------|------------------------|------------------------------------|----------------|
|                 |                 |                                     |           | hp            | (kW)  | hp          | (kW)  | lb             | (kg)    |                        |                                    |                |
| Long            |                 | 1100DT                              | Diesel    | 78            | (58)  | 92          | (69)  | 8,890          | (4,032) | 540 or 1,000           | 15.0                               | (56.8)         |
|                 |                 | Drago 2RM<br>Drago 4RM              | Diesel    | 76            | (57)  | 92          | (69)  | 7,790          | (3,533) | 540 or 1,000           | 7.6                                | (28.8)         |
| W80             | Intl. Harvester | Hydro 186*                          | Diesel    | 83            | (62)  | 105         | (78)  | 11,160         | (5,062) | 540 or 1,000           | 12.0                               | (45.4)         |
| W85             | Deutz           | DX110<br>DX110A*                    | Diesel    | 85            | (63)  | 100         | (75)  | 9,700          | (4,400) | 540 or 1,000           | 14.7                               | (55.7)         |
| Fiat            |                 | 1000S<br>1000DTS*                   | Diesel    | 89            | (66)  | 105         | (78)  | 7,500          | (3,402) | 540 or 1,000           | 11.5                               | (43.5)         |
|                 |                 |                                     | Diesel    | 89            | (66)  | 105         | (78)  | 8,750          | (3,969) | 540 or 1,000           | 11.5                               | (43.5)         |
| Long            |                 | 1310                                | Diesel    | 85            | (63)  | 105         | (78)  | 9,000          | (4,082) | 540 or 1,000           | 15.0                               | (56.8)         |
| Massey Ferguson |                 | MF2675                              | Diesel    | 85            | (63)  | 100         | (75)  | 11,000         | (4,900) | 540 to 1,000           | 31.6                               | (119.6)        |
| Same'           |                 | Buffalo 120 2RM<br>Buffalo 120 4RM* | Diesel    | 89            | (66)  | 108         | (81)  | 9,040          | (4,100) | 540 or 1,000           | 10.0                               | (37.9)         |
|                 |                 |                                     | Diesel    | 89            | (66)  | 108         | (81)  | 9,550          | (4,332) | 540 or 1,000           | 10.0                               | (37.9)         |
| Steyr           |                 | 1108<br>1108A*                      | Diesel    | 85            | (63)  | 115         | (86)  | 7,804          | (3,540) | 540 or 1,000           | 9.4                                | (35.6)         |
|                 |                 |                                     | Diesel    | 85            | (63)  | 115         | (86)  | 8,550          | (3,878) | 540 or 1,000           | 9.4                                | (35.6)         |
|                 |                 | 8120                                | Diesel    | 87            | (65)  | 100         | (75)  | 8,774          | (3,980) | 540 or 1,000           | 9.2                                | (34.8)         |
|                 |                 | 8120A*                              | Diesel    | 87            | (65)  | 100         | (75)  | 9,610          | (3,452) | 540 or 1,000           | 9.2                                | (34.8)         |
| W90             | Allis Chalmers  | 7000                                | Diesel    | 93            | (69)  | 106         | (79)  | 8,793          | (3,988) | 540 or 1,000           | 15.0                               | (56.8)         |
| J. I. Case      |                 | 2090                                | Diesel    | 92            | (69)  | 108         | (81)  | 10,950         | (4,967) | 540 or 1,000           | 22.0                               | (83.3)         |
| John Deere      |                 | 4240*<br>4240 Hi Crop               | Diesel    | 93            | (69)  | 110         | (82)  | 11,901         | (5,398) | 540 or 1,000           | 20.0                               | (75.7)         |
|                 |                 |                                     | Diesel    | 94            | (70)  | 110         | (82)  | 10,918         | (4,952) | 540 or 1,000           | 20.0                               | (75.7)         |
| Deutz           |                 | D10006<br>D10006A*                  | Diesel    | 91            | (68)  | 105         | (78)  | 8,061          | (3,656) | 540 or 1,000           | 10.5                               | (39.8)         |
|                 |                 |                                     | Diesel    | 91            | (68)  | 105         | (78)  | 8,790          | (3,987) | 540 or 1,000           | 9.5                                | (36.0)         |
| Ford            |                 | TW10                                | Diesel    | 94            | (70)  | 110         | (82)  | 9,800          | (4,445) | 540 or 1,000           | 16.2                               | (61.3)         |
| Intl. Harvester |                 | 986*                                | Diesel    | 95            | (71)  | 106         | (79)  | 10,900         | (4,944) | 540 or 1,000           | 13.0                               | (49.2)         |
| Long            |                 | 1310DT*                             | Diesel    | 90            | (67)  | 105         | (78)  | 9,990          | (4,531) | 540 or 1,000           | 15.0                               | (56.8)         |
| White           |                 | 2-105*                              | Diesel    | 91            | (68)  | 106         | (79)  | 11,350         | (5,148) | 540 or 1,000           | 20.0                               | (75.7)         |
| W95             | John Deere      | 4240 Row Crop                       | Diesel    | 95            | (71)  | 111         | (83)  | 10,900         | (4,944) | 540 or 1,000           | 20.0                               | (75.7)         |
| Steyr           |                 | 8140<br>8140A*                      | Diesel    | 99            | (74)  | 122         | (91)  | 10,250         | (4,649) | 1,000                  | 10.8                               | (40.9)         |
|                 |                 |                                     | Diesel    | 99            | (74)  | 122         | (91)  | 11,640         | (5,280) | 1,000                  | 10.8                               | (40.9)         |
| W100            | Allis Chalmers  | 7020<br>7020PS                      | Diesel    | 107           | (80)  | 124         | (92)  | 11,439         | (5,189) | 540 or 1,000           | 17.0                               | (64.4)         |
|                 |                 |                                     | Diesel    | 105           | (78)  | 124         | (92)  | 11,630         | (5,275) | 540 or 1,000           | 17.0                               | (64.4)         |
| J. I. Case      |                 | 2290                                | Diesel    | 109           | (81)  | 128         | (95)  | 11,070         | (4,568) | 540 or 1,000           | 22.0                               | (75.7)         |
| John Deere      |                 | 4440*                               | Diesel    | 108           | (81)  | 130         | (97)  | 12,781         | (5,797) | 540 or 1,000           | 20.0                               | (75.7)         |
| Massey Ferguson |                 | MF2705                              | Diesel    | 102           | (76)  | 120         | (89)  | 11,200         | (5,080) | 540 or 1,000           | 31.6                               | (119.6)        |
| W110            | John Deere      | 4440 Hi Crop<br>4440 Row Crop       | Diesel    | 111           | (83)  | 130         | (97)  | 11,072         | (5,022) | 540 or 1,000           | 20.0                               | (75.7)         |
|                 |                 |                                     | Diesel    | 113           | (84)  | 131         | (98)  | 11,780         | (5,343) | 540 or 1,000           | 20.0                               | (75.7)         |
| Deutz           |                 | D13006<br>D13006A*                  | Diesel    | 110           | (82)  | 126         | (94)  | 9,020          | (4,091) | 1,000                  | 10.8                               | (40.9)         |
|                 |                 |                                     | Diesel    | 110           | (82)  | 126         | (94)  | 10,185         | (4,620) | 1,000                  | 9.5                                | (36.0)         |
|                 |                 | DX140                               | Diesel    | 111           | (83)  | 131         | (98)  | 11,500         | (5,216) | 1,000                  | 18.2                               | (68.9)         |
|                 |                 | DX140A*                             | Diesel    | 111           | (83)  | 131         | (98)  | 12,500         | (5,670) | 1,000                  | 18.2                               | (68.9)         |
|                 |                 | DX160                               | Diesel    | 119           | (89)  | 140         | (104) | 11,900         | (5,398) | 1,000                  | 18.2                               | (68.9)         |
|                 |                 | DX160*                              | Diesel    | 119           | (89)  | 140         | (104) | 12,900         | (5,851) | 1,000                  | 18.2                               | (68.9)         |
| Fiat            |                 | 1300S<br>1300DTS*                   | Diesel    | 115           | (86)  | 135         | (101) | 9,750          | (4,223) | 540 or 1,000           | 12.4                               | (46.9)         |
|                 |                 |                                     | Diesel    | 115           | (86)  | 135         | (101) | 11,000         | (4,990) | 540 or 1,000           | 12.4                               | (46.9)         |
| Ford            |                 | TW20                                | Diesel    | 115           | (86)  | 135         | (101) | 10,900         | (4,944) | 540 or 1,000           | 15.5                               | (58.7)         |
| Intl. Harvester |                 | 1086*                               | Diesel    | 114           | (85)  | 131         | (98)  | 11,700         | (5,307) | 540 or 1,000           | 13.0                               | (49.2)         |
| Massey Ferguson |                 | MF2745                              | Diesel    | 119           | (89)  | 140         | (104) | 12,500         | (5,670) | 540 or 1,000           | 34.2                               | (129.5)        |
| White           |                 | 2-135*                              | Diesel    | 118           | (88)  | 138         | (103) | 13,875         | (6,294) | 1,000                  | 20.0                               | (75.7)         |
| W120            | Allis Chalmers  | 7045<br>7045PS                      | Diesel    | 128           | (95)  | 147         | (110) | 12,015         | (5,450) | 540 or 1,000           | 17.0                               | (64.4)         |
|                 |                 |                                     | Diesel    | 123           | (92)  | 145         | (108) | 12,220         | (5,543) | 540 or 1,000           | 17.0                               | (64.4)         |
| Intl. Harvester |                 | 1486*                               | Diesel    | 127           | (95)  | 146         | (109) | 11,800         | (5,352) | 1,000                  | 13.0                               | (49.2)         |
| Steyr           |                 | 8160A*                              | Diesel    | 128           | (95)  | 150         | (112) | 12,323         | (5,590) | 1,000                  | 10.8                               | (40.9)         |
| W130            | J. I. Case      | 2390                                | Diesel    | 136           | (101) | 160         | (119) | 14,270         | (6,473) | 1,000                  | 24.0                               | (90.9)         |
| John Deere      |                 | 4640*<br>4640 Row Crop              | Diesel    | 130           | (97)  | 156         | (116) | 15,351         | (6,963) | 1,000                  | 20.0                               | (75.7)         |
|                 |                 |                                     | Diesel    | 135           | (101) | 156         | (116) | 14,350         | (6,509) | 1,000                  | 20.0                               | (75.7)         |
| Ford            |                 | TW30                                | Diesel    | 139           | (104) | 163         | (122) | 13,050         | (5,919) | 540 or 1,000           | 15.5                               | (58.7)         |
| Massey Ferguson |                 | MF2775                              | Diesel    | 139           | (104) | 166         | (124) | 13,300         | (6,033) | 1,000                  | 34.2                               | (129.5)        |
| White           |                 | 2-155*                              | Diesel    | 140           | (104) | 158         | (118) | 14,175         | (6,430) | 1,000                  | 20.0                               | (75.7)         |

## Comparative Specifications for Rubber-Tired Tractors

| Tractor Size | Make            | Model         | Fuel Type | Drawbar Power |       | Rated Power |       | Minimum Weight |         | Standard PTO Speed RPM |      | Hydraulic Capacity gal/min (l/min) |           | Hitch Category |
|--------------|-----------------|---------------|-----------|---------------|-------|-------------|-------|----------------|---------|------------------------|------|------------------------------------|-----------|----------------|
|              |                 |               |           | hp.           | (kW)  | hp.         | (kW)  | lb             | (kg)    | RPM                    |      |                                    |           |                |
| W140         | Allis Chalmers  | 7060          | Diesel    | 141           | (105) | 162         | (121) | 12,230         | (5,547) | 540 or 1,000           | 17.0 | (64.4)                             | III       |                |
|              |                 | 7060PS        | Diesel    | 144           | (107) | 161         | (120) | 12,230         | (5,547) | 540 or 1,000           | 17.0 | (64.4)                             | III       |                |
| W150         | Intl. Harvester | 1586          | Diesel    | 140           | (104) | 162         | (121) | 12,480         | (5,661) | 1,000                  | 13.0 | (49.2)                             | III       |                |
|              | Allis Chalmers  | 7080          | Diesel    | 154           | (115) | 182         | (136) | 13,489         | (6,119) | 1,000                  | 18.0 | (68.1)                             | III       |                |
| W150         | J. I. Case      | 2590          | Diesel    | 153           | (114) | 180         | (134) | 14,875         | (6,767) | 1,000                  | 24.0 | (90.9)                             | III or II |                |
|              | John Deere      | 4840 Row Crop | Diesel    | 157           | (117) | 181         | (135) | 14,900         | (6,759) | 1,000                  | 20.0 | (75.7)                             | III       |                |
|              | Massey Ferguson | MF2805        | Diesel    | 158           | (118) | 195         | (145) | 13,500         | (6,124) | 1,000                  | 33.0 | (124.9)                            | II or III |                |
|              | White           | 2-180*        | Diesel    | 153           | (114) | 180         | (134) | 15,540         | (7,049) | 1,000                  | 22.0 | (83.3)                             | II or III |                |

\*Available with front wheel drive option

### All-Wheel Drive Agricultural Tractors

|      |                 |                    |        |     |       |     |       |        |          |              |      |         |           |
|------|-----------------|--------------------|--------|-----|-------|-----|-------|--------|----------|--------------|------|---------|-----------|
| W20  | Holder          | A30                | Diesel | 20  | (15)  | 24  | (18)  | 2,189  | (993)    | 540          | 6.9  | (26.1)  | I         |
| W30  | Holder          | A45                | Diesel | 31  | (23)  | 36  | (27)  | 2,464  | (1,118)  | 540          | 6.9  | (26.1)  | I         |
|      |                 | A55                | Diesel | 31  | (23)  | 36  | (27)  | 3,102  | (1,407)  | 540          | 6.9  | (26.1)  | I         |
| W35  | Ferrari         | 85                 | Diesel | 38  | (28)  | 48  | (36)  | 3,000  | (1,361)  | 540 or 1,000 | 5.5  | (20.8)  | I         |
| W40  | Holder          | A60                | Diesel | 41  | (31)  | 46  | (34)  | 3,850  | (1,746)  | 540 or 1,000 | 8.0  | (30.3)  | II        |
|      | Versatile       | 150                | Diesel | 40  | (30)  | 54  | (40)  | 7,500  | (3,402)  | 540          | 15.0 | (56.8)  | II        |
| W45  | Ferrari         | 86                 | Diesel | 48  | (36)  | 60  | (45)  | 3,400  | (1,542)  | 540 or 1,000 | 5.5  | (20.8)  | I         |
| W95  | Muir-Hill       | 111                | Diesel | 99  | (74)  | 116 | (87)  | 10,700 | (4,853)  | 540 or 1,000 | 10.7 | (40.5)  | II        |
| W110 | Muir-Hill       | 121                | Diesel | 112 | (84)  | 132 | (98)  | 10,700 | (4,853)  | 540 or 1,000 | 10.7 | (40.5)  | II        |
| W120 | MRS             | A80B               | Diesel | 123 | (92)  | 152 | (113) | 14,300 | (6,486)  | N/A          | 20.0 | (75.7)  | N/A       |
| W130 | Intl. Harvester | 4186               | Diesel | 130 | (97)  | 151 | (113) | 15,900 | (7,212)  | 1,000        | 18.0 | (68.1)  | III       |
|      | White           | 4-150              | Diesel | 133 | (99)  | 152 | (113) | 14,500 | (6,577)  | 1,000        | 20.0 | (75.7)  | II or III |
| W140 | Muir-Hill       | 171                | Diesel | 145 | (108) | 177 | (132) | 14,000 | (6,350)  | 540 or 1,000 | 17.5 | (66.2)  | III       |
|      | Versatile       | 500                | Diesel | 145 | (108) | 160 | (119) | 15,000 | (6,804)  | 540 or 1,000 | 24.0 | (90.9)  | III       |
| W150 | Allis Chalmers  | 7580               | Diesel | 161 | (120) | 186 | (139) | 17,261 | (7,829)  | 1,000        | 17.0 | (64.4)  | III       |
|      | Belarus         | 7010               | Diesel | 170 | (217) | 200 | (149) | 27,889 | (12,650) | 1,000        | 30.1 | (113.9) | III       |
|      | J. I. Case      | 2470               | Diesel | 151 | (113) | 177 | (132) | 15,550 | (7,053)  | 1,000        | 17.0 | (64.4)  | III       |
|      | John Deere      | 8440               | Diesel | 160 | (119) | 175 | (131) | 22,210 | (10,074) | 1,000        | 18.0 | (68.1)  | III       |
|      | Ford            | FW20               | Diesel | 155 | (116) | 230 | (172) | 24,775 | (11,238) | 540 or 1,000 | 20.0 | (75.7)  | III       |
|      | MRS             | A85                | Diesel | 164 | (122) | 196 | (146) | 17,300 | (7,847)  | N/A          | 20.0 | (75.7)  | N/A       |
|      | Steiger         | Wildcat III RC210  | Diesel | 171 | (128) | 210 | (157) | 22,000 | (9,979)  | N/A          | 20.0 | (75.7)  | III       |
|      | White           | 4-180              | Diesel | 156 | (116) | 181 | (135) | 17,900 | (8,119)  | 1,000        | 20.0 | (75.7)  | II or III |
|      |                 | 4-210              | Diesel | 153 | (114) | 180 | (134) | 22,320 | (10,124) | 1,000        | 23.5 | (89.0)  | II or III |
| W175 | J. I. Case      | 2670               | Diesel | 195 | (145) | 222 | (166) | 16,370 | (7,425)  | 1,000        | 17.0 | (64.4)  | III       |
|      | Intl. Harvester | 4386               | Diesel | 182 | (136) | 230 | (172) | 19,875 | (9,015)  | N/A          | 16.0 | (60.6)  | III       |
|      | Massey Ferguson | 4840               | Diesel | 187 | (139) | 220 | (164) | 27,000 | (12,247) | 1,000        | 20.0 | (75.7)  | III       |
|      | MRS             | A92                | Diesel | 188 | (140) | 196 | (146) | 25,300 | (11,476) | N/A          | 20.0 | (75.7)  | N/A       |
|      | Steiger         | Bearcat III PT 225 | Diesel | 188 | (140) | 225 | (168) | 26,700 | (12,111) | 540 to 1,000 | 20.0 | (75.7)  | III       |
|      | Versatile       | 835                | Diesel | 182 | (136) | 198 | (148) | 19,750 | (8,958)  | 1,000        | 23.5 | (89.0)  | III       |
|      |                 | 855                | Diesel | 198 | (148) | 212 | (158) | 19,830 | (8,995)  | 1,000        | 23.5 | (89.0)  | III       |
| W200 | Allis Chalmers  | 8550               | Diesel | 224 | (167) | 254 | (189) | 26,400 | (11,975) | 1,000        | 17.0 | (64.4)  | III       |
|      | Big Bud         | HN360              | Diesel | 306 | (228) | 360 | (268) | 39,000 | (17,690) | N/A          | 38.0 | (143.9) | N/A       |
|      |                 | HN400              | Diesel | 340 | (254) | 400 | (298) | 40,000 | (18,144) | N/A          | 38.0 | (143.9) | N/A       |
|      |                 | HN450              | Diesel | 383 | (286) | 450 | (336) | 42,000 | (19,051) | N/A          | 38.0 | (143.9) | N/A       |
|      |                 | HN525              | Diesel | 446 | (333) | 525 | (391) | 45,000 | (20,412) | N/A          | 38.0 | (143.9) | N/A       |
|      |                 | HN747              | Diesel | 633 | (472) | 760 | (567) | 95,000 | (43,091) | N/A          | 38.0 | (143.9) | N/A       |
|      | J. I. Case      | 2870               | Diesel | 220 | (164) | 252 | (188) | 18,500 | (8,391)  | 1,000        | 22.0 | (83.3)  | III       |
|      | John Deere      | 8640               | Diesel | 202 | (151) | 225 | (168) | 24,750 | (11,226) | 1,000        | 18.0 | (68.1)  | III       |
|      | Ford            | FW30               | Diesel | 205 | (153) | 295 | (220) | 25,320 | (11,485) | 540 or 1,000 | 20.0 | (75.7)  | III       |
|      |                 | FW40               | Diesel | 230 | (172) | 295 | (220) | 25,320 | (11,485) | 540 or 1,000 | 20.0 | (75.7)  | III       |
|      |                 | FW50               | Diesel | 260 | (194) | 320 | (239) | 26,171 | (11,871) | 540 or 1,000 | 20.0 | (75.7)  | III       |

## Comparative Specifications for Rubber-Tired Tractors

| Tractor Size    | Make               | Model | Fuel Type | Drawbar Power |           | Rated Power |          | Minimum Weight |              | Standard PTO Speed RPM | Hydraulic Capacity gal/min (l/min) | Hitch Category |
|-----------------|--------------------|-------|-----------|---------------|-----------|-------------|----------|----------------|--------------|------------------------|------------------------------------|----------------|
|                 |                    |       |           | hp (kW)       | hp (kW)   | hp (kW)     | hp (kW)  | lb (kg)        | (kg)         |                        |                                    |                |
| Intl. Harvester | 4586               |       | Diesel    | 235 (175)     | 350 (261) | 22,400      | (10,160) | N/A            | 19.0 (71.9)  | N/A                    | N/A                                |                |
|                 | 4786               |       | Diesel    | 260 (194)     | 350 (261) | 23,600      | (10,705) | N/A            | 19.0 (71.9)  | N/A                    | N/A                                |                |
| MRS             | A95                |       | Diesel    | 219 (163)     | 270 (201) | 30,300      | (13,744) | N/A            | 25.0 (94.6)  | N/A                    | N/A                                |                |
|                 | A100               |       | Diesel    | 260 (194)     | 312 (233) | 33,300      | (15,105) | N/A            | 25.0 (94.6)  | N/A                    | N/A                                |                |
| Massey Ferguson | MF4880             |       | Diesel    | 230 (172)     | 270 (201) | 27,000      | (12,247) | 1,000          | 20.0 (75.7)  | III                    |                                    |                |
| Rome            | 375C               |       | Diesel    | 319 (238)     | 375 (280) | 36,000      | (16,329) | N/A            | 35.0 (132.5) | N/A                    | N/A                                |                |
|                 | 475C               |       | Diesel    | 404 (301)     | 475 (354) | 30,300      | (13,744) | N/A            | 35.0 (132.5) | N/A                    | N/A                                |                |
| Steiger         | Cougar 111 ST251   |       | Diesel    | 206 (154)     | 251 (187) | 26,700      | (12,111) | N/A            | 20.0 (75.7)  | III                    |                                    |                |
|                 | Cougar 111 ST270   |       | Diesel    | 229 (171)     | 270 (201) | 25,970      | (11,780) | N/A            | 20.0 (75.7)  | III                    |                                    |                |
|                 | Cougar 111 PT270   |       | Diesel    | 225 (168)     | 270 (201) | 26,830      | (12,170) | 540 to 1,000   | 20.0 (75.7)  | III                    |                                    |                |
|                 | Panther 111 PTA297 |       | Diesel    | 250 (186)     | 297 (221) | 27,350      | (12,406) | 540 to 1,000   | 20.0 (75.7)  | III                    |                                    |                |
|                 | Panther 111 ST310  |       | Diesel    | 262 (195)     | 310 (231) | 26,850      | (12,179) | N/A            | 20.0 (75.7)  | III                    |                                    |                |
|                 | Panther 111 ST325  |       | Diesel    | 282 (210)     | 325 (242) | 26,670      | (12,097) | N/A            | 20.0 (75.7)  | III                    |                                    |                |
|                 | Panther 111 ST350  |       | Diesel    | 308 (230)     | 350 (261) | 26,950      | (12,224) | N/A            | 20.0 (75.7)  | III                    |                                    |                |
|                 | Panther 111 PT350  |       | Diesel    | 312 (233)     | 350 (261) | 27,330      | (12,397) | 540 to 1,000   | 20.0 (75.7)  | III                    |                                    |                |
|                 | Tiger 111 ST450    |       | Diesel    | 387 (289)     | 450 (336) | 43,060      | (19,532) | N/A            | 25.0 (94.6)  | N/A                    |                                    |                |
| Versatile       | 875                |       | Diesel    | 228 (170)     | 248 (185) | 20,850      | (9,456)  | 1,000          | 23.5 (89.0)  | III                    |                                    |                |
|                 | 935                |       | Diesel    | 260 (194)     | 282 (210) | 19,771      | (8,968)  | 1,000          | 25.0 (94.6)  | III                    |                                    |                |
|                 | 950                |       | Diesel    | 272 (203)     | 300 (224) | 20,609      | (9,348)  | 1,000          | 25.0 (94.6)  | III                    |                                    |                |

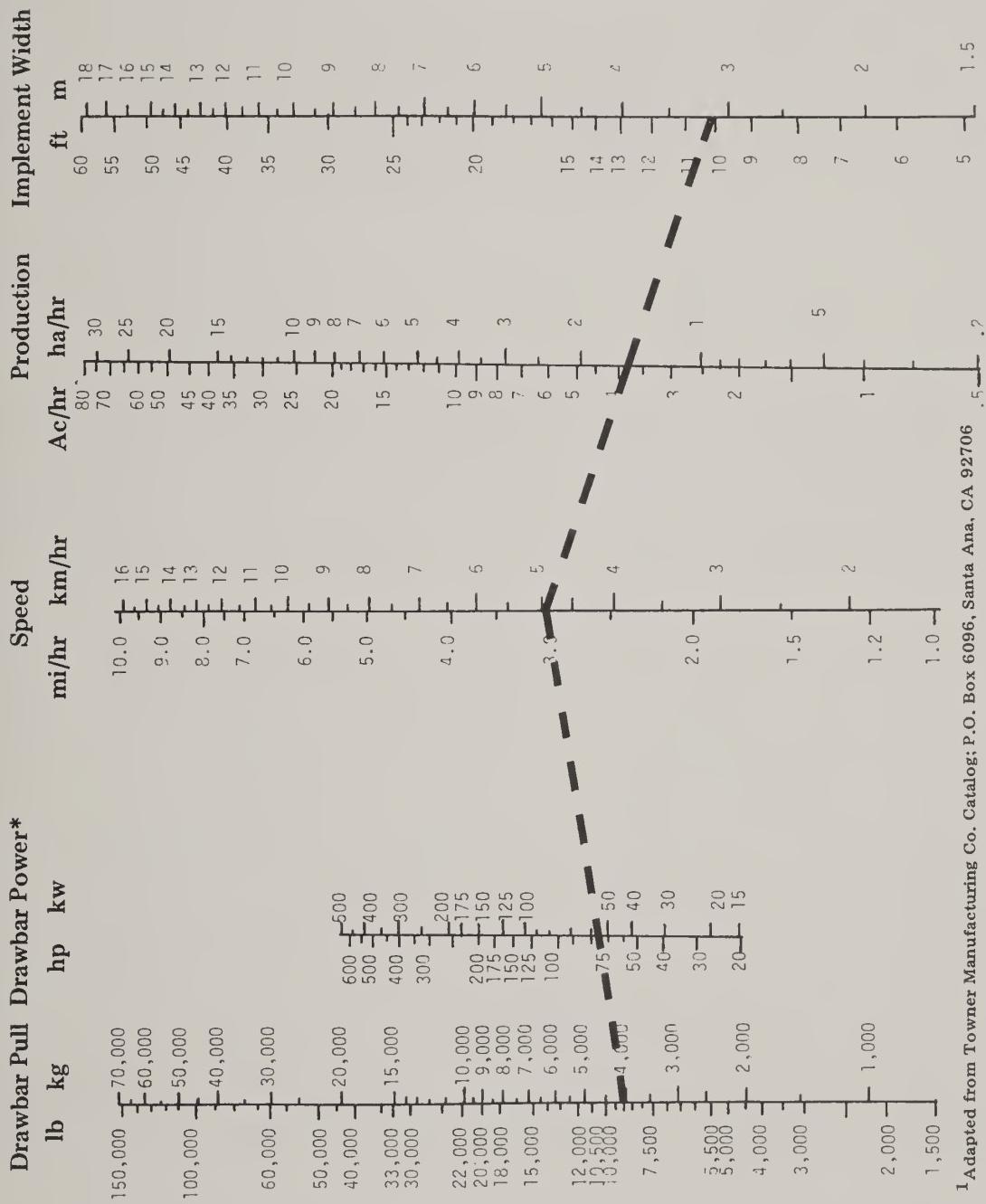
Comparative Specifications<sup>1</sup> for Crawler Tractors

| Tractor Size | Make            | Model  | Net Engine Power at the Flywheel |                                      | Weight (kw)                                    | Tractor Gage in (cm)                                     | Track Length in (cm)   |  |
|--------------|-----------------|--|----------------------------------|--------------------------------------|--|--|--|--|
|              |                 |  | hp                               | (kw)                                 |  |  |  |  |
| T-1          | Massey Ferguson | MFD200C  | 44                               | (33)                                 | 10,230   | (4,640)  | 48.0 (122)   | 62.3 (158)   |
| T-2          | J. I. Case      | 350  | 39                               | (29)                                 | 5,905  | (2,678)  | 48.0 (122)   | 63.0 (160)   |
| T-3          | J. I. Case      | 450  | 53                               | (40)                                 | 8,850  | (4,014)  | 52.0 (132)   | 68.5 (174)   |
|              | John Deere      | JD350-C  | 42                               | (31)                                 | 8,160  | (3,701)  | 48.0 (122)   | 69.3 (176)   |
|              | Intl. Harvester | 500E-PS  | 44                               | (33)                                 | 8,670  | (3,933)  | 50.0 (127)   | 68.0 (173)   |
| T-4          | Caterpillar     | D3-PS<br>D3PS-LGP<br>D4E-SA                          | 62<br>62<br>68                   | (46)<br>(46)<br>(51)                 | 13,980<br>14,725<br>18,260                     | (6,341)<br>(6,679)<br>(8,283)                            | 56.0 (142)<br>65.0 (165)<br>60.0 (152)                             | 71.8 (182)<br>81.4 (207)<br>72.0 (183)                               |
|              | John Deere      | JD450-C<br>JD550                                     | 65<br>72                         | (48)<br>(54)                         | 11,600<br>12,300                               | (5,262)<br>(5,579)                                       | 52.0 (132)<br>52.0 (132)   | 72.8 (185)<br>72.8 (185)   |
|              | Intl. Harvester | TD-7E-PS   | 65                               | (48)                                 | 13,632   | (6,183)  | 52.0 (132)   | 72.0 (183)   |
|              | Komatsu         | D31A-16<br>D31P-16                                   | 63<br>63                         | (47)<br>(47)                         | 15,020<br>15,850                               | (6,813)<br>(7,189)                                       | 57.1 (145)<br>57.1 (145)   | 86.0 (188)<br>86.0 (218)   |
| T-5          | J. I. Case      | 850B<br>1150C  | 75<br>105                        | (56)<br>(78)                         | 13,600<br>19,700                               | (6,169)<br>(8,936)                                       | 60.0 (152)<br>62.0 (157)   | 78.0 (198)<br>87.0 (221)   |
|              | Caterpillar     | D4E-DD<br>D4E-PS<br>D4DLGP-DD<br>D4DLGP-PS<br>D5B-SA | 75<br>75<br>75<br>75<br>90       | (56)<br>(56)<br>(56)<br>(56)<br>(67) | 19,330<br>19,500<br>22,240<br>22,100<br>23,600 | (8,767)<br>(8,845)<br>(10,089)<br>(10,029)<br>(10,705)   | 60.0 (152)<br>60.0 (152)<br>70.0 (178)<br>70.0 (178)<br>74.0 (188) | 72.0 (183)<br>72.0 (183)<br>87.0 (221)<br>87.0 (221)<br>86.0 (218)   |
|              | Fiat-Allis      | 8-B  | 88                               | (66)                                 | 21,839   | (9,906)  | 60.3 (153)   | 85.0 (216)   |
|              | Intl. Harvester | TD-8E-PS   | 78                               | (58)                                 | 16,697   | (7,574)  | 54.0 (137)   | 74.8 (190)   |
|              | Komatsu         | D45A-1<br>D45P-1                                     | 90<br>90                         | (67)<br>(67)                         | 22,500<br>24,395                               | (10,206)<br>(11,065)                                     | 60.6 (154)<br>69.3 (176)   | 81.1 (206)<br>102.0 (259)  |
| T-6          | Caterpillar     | D5B-DD<br>D5B-PS<br>D5BGP-DD<br>D5BLGP-PS<br>D6C-SA  | 105<br>105<br>105<br>105<br>125  | (78)<br>(78)<br>(78)<br>(78)<br>(93) | 24,200<br>24,800<br>32,400<br>32,400<br>29,500 | (11,431)<br>(11,703)<br>(14,696)<br>(14,696)<br>(13,381) | 74.0 (188)<br>74.0 (188)<br>81.0 (206)<br>81.0 (206)<br>74.0 (188) | 87.0 (221)<br>87.0 (221)<br>111.0 (282)<br>111.0 (282)<br>93.0 (236) |
|              | John Deere      | JD750  | 110                              | (82)                                 | 29,055   | (13,179)   | 74.0 (188)   | 90.0 (229)   |
|              | Fiat-Allis      | 10-B   | 110                              | (82)                                 | 28,150   | (12,769)   | 67.8 (172)   | 90.0 (229)   |
|              | Komatsu         | D52A-16  | 110                              | (82)                                 | 28,260   | (12,819)   | 74.0 (188)   | 96.2 (219)   |
| T-7          | J. I. Case      | 1450   | 130                              | (97)                                 | 23,800   | (10,796)   | 74.0 (188)   | 94.0 (239)   |
|              | Caterpillar     | D6C-DD<br>D6C-PS<br>D6CLGP-PS                        | 140<br>140<br>140                | (104)<br>(104)<br>(104)              | 32,500<br>31,500<br>38,300                     | (14,742)<br>(14,288)<br>(17,373)                         | 74.0 (188)<br>74.0 (188)<br>83.0 (211)                             | 93.0 (236)<br>93.0 (236)<br>113.4 (288)                              |
|              | John Deere      | JD850  | 145                              | (108)                                | 36,785   | (16,685)   | 74.0 (188)   | 95.0 (241)   |
|              | Fiat-Allis      | 14-C   | 150                              | (112)                                | 35,500   | (16,103)   | 73.6 (187)   | 95.0 (241)   |
|              | Intl. Harvester | TD-15C-PS  | 140                              | (104)                                | 24,153   | (10,956)   | 74.0 (188)   | 96.2 (244)   |
|              | Komatsu         | D65E-6<br>D60P-6<br>D65P-6                           | 155<br>140<br>155                | (116)<br>(104)<br>(116)              | 38,157<br>41,325<br>43,064                     | (17,308)<br>(18,745)<br>(19,534)                         | 74.0 (188)<br>80.7 (205)<br>80.7 (205)                             | 103.7 (263)<br>123.6 (314)<br>123.6 (314)                            |
| T-8          | Fiat-Allis      | 16-B-PS  | 195                              | (145)                                | 49,500   | (22,453)   | 78.0 (198)   | 107.5 (273)  |

<sup>1</sup>/ Specifications were obtained from:McGraw-Hill Book Co., Inc. 1979. Specs-dozers (track type).  
McGraw-Hill's Construction Contracting 61(1):38-41.

## Comparative Specifications for Crawler Tractors

| Tractor Size | Make            | Model     | Net Engine Power at the Flywheel |       | Weight lb (kw)   | Tractor Gage in (cm) | Track Length in (cm) |
|--------------|-----------------|-----------|----------------------------------|-------|------------------|----------------------|----------------------|
|              |                 |           | hp (149)                         | (kw)  |                  |                      |                      |
| T-9          | Caterpillar     | D7G-DD    | 200                              | (149) | 44,000 (19,958)  | 78.0 (198)           | 107.0 (272)          |
|              |                 | D7G-PS    | 200                              | (149) | 44,300 (20,094)  | 78.0 (198)           | 107.0 (272)          |
|              |                 | D7GLGP-OD | 200                              | (149) | 51,200 (23,224)  | 86.0 (218)           | 120.0 (305)          |
|              |                 | D7GLGP-PS | 200                              | (149) | 51,500 (23,360)  | 86.0 (218)           | 120.0 (305)          |
|              | Intl. Harvester | TD-20E-PS | 210                              | (157) | 39,908 (18,102)  | 78.0 (198)           | 108.5 (276)          |
|              | Komatsu         | D85E-12   | 200                              | (149) | 52,689 (23,899)  | 78.7 (200)           | 120.1 (305)          |
|              | Terex           | 82-20B    | 205                              | (153) | 35,905 (16,286)  | 78.0 (198)           | 107.0 (272)          |
| T-10         | Terex           | 82-30B    | 260                              | (194) | 50,534 (22,922)  | 78.0 (198)           | 124.0 (315)          |
| T-11         | Caterpillar     | D8K-DD    | 300                              | (224) | 69,300 (31,434)  | 84.0 (213)           | 124.0 (315)          |
|              |                 | D8K-PS    | 300                              | (224) | 70,300 (31,888)  | 84.0 (213)           | 124.0 (315)          |
|              | Fiat-Allis      | 21C       | 300                              | (224) | 71,650 (32,500)  | 84.0 (213)           | 124.0 (315)          |
|              | Intl. Harvester | TD-25C-PS | 310                              | (231) | 58,243 (26,419)  | 106.0 (269)          | 124.0 (315)          |
|              | Komatsu         | D150A-1   | 300                              | (224) | 76,080 (34,509)  | 108.3 (275)          | 124.4 (316)          |
| T-12         | Caterpillar     | D10H-PS   | 410                              | (305) | 93,600 (42,456)  | 90.0 (229)           | 132.0 (335)          |
|              |                 | DD9H-PS   | 820                              | (611) | 184,910 (83,874) | 90.0 (229)           | 264.0 (671)          |
|              | Fiat-Allis      | 31        | 425                              | (317) | 110,850 (50,281) | 100.0 (254)          | 132.5 (337)          |
| T-13         | Komatsu         | D355A-3   | 410                              | (305) | 104,735 (47,507) | 89.0 (226)           | 132.5 (337)          |
|              | Terex           | 82-50     | 370                              | (276) | 69,735 (31,631)  | 84.0 (213)           | 131.4 (334)          |
|              | Caterpillar     | D10       | 700                              | (522) | 172,200 (78,109) | 114.0 (290)          | 154.0 (391)          |
|              | Fiat-Allis      | 41-B      | 524                              | (391) | 142,500 (64,637) | 100.0 (254)          | 143.5 (364)          |
|              | Komatsu         | D455A-1   | 620                              | (462) | 178,700 (81,057) | 164.3 (417)          | 153.9 (391)          |

Power and Production Chart<sup>1</sup>

<sup>1</sup> Adapted from Towner Manufacturing Co. Catalog; P.O. Box 6096, Santa Ana, CA 92706

\*Drawbar power is approximately 70 percent of the flywheel power.



# Appendix D

Forage plants commonly seeded on range and other perennial pasture

| Common and scientific name                           | Rating of plant characteristics <sup>a</sup> |                       |                   |                   |                   |                               |          |             |        |                      | Regional adaptations <sup>b</sup> |              |        |             |        |                                     |                     |              |   |  | Principal named varieties <sup>c</sup>   | Special considerations and adaptations <sup>d</sup> |  |
|--|--|-----------------------|-------------------|-------------------|-------------------|-------------------------------|----------|-------------|--------|----------------------|-----------------------------------|--------------|--------|-------------|--------|-------------------------------------|---------------------|--------------|---|--|--|---|--|
|  | Soil adaptation                              |                       |                   |                   |                   | Forage usability <sup>e</sup> |          |             |        |                      | Grazing tolerance <sup>f</sup>    |              |        |             |        | Season of introduction <sup>g</sup> |                     |              |   |  |  |   |  |
|  | Stability to erosion                         | Depth of infiltration | Sand infiltration | Clay infiltration | Silt infiltration | Early spring                  | Summer   | Late spring | Winter | High water tolerance | Low water tolerance               | Early spring | Summer | Late spring | Winter | High water tolerance                | Low water tolerance | Early spring | Summer  |  |  |   |  |
| Alliaria officinalis (Garlic mustard)                | 210<br>(463)                                 | 4.1<br>(4.6)          | 1<br>1-2          | 1-2<br>1-2        | 2<br>1            | 1<br>2                        | 2<br>1-2 | 1<br>1      | 1<br>1 | 3<br>1-2             | 1<br>1                            | 1<br>1       | 1<br>1 | 1<br>1      | 1<br>1 | 1<br>1                              | 1<br>1              | 1<br>1       | R<br>R  | Ranger, Lada, Rambler, Teton   | Most widely used legume for range and pasture mixtures. Adapted to irrigated pasture and dryland sites receiving 15" precip or more. |   |  |
| Bahiagrass ( <i>Paspalum notatum</i> )               | 166<br>(366)                                 | 5.2<br>(5.8)          | 1<br>1-2          | 2<br>3            | 1<br>1            | 1<br>1                        | 1<br>1   | 2<br>1      | 2<br>1 | 3<br>2               | 1<br>1                            | 1<br>1       | 1<br>1 | 1<br>1      | 1<br>1 | 1<br>1                              | 1<br>1              | R<br>R       | Prairie, Tifi, Argentine  | Keep young by grazing or mowing. Rhizomatous.  |  |   |  |
| Bermudagrass ( <i>Cynodon dactylon</i> )             | 1787<br>(3940)                               | 9.7<br>(1.0)          | 2<br>1            | 1-2<br>3          | 1<br>1            | 1<br>1                        | 2<br>1   | 3<br>1      | 1<br>1 | 2<br>2               | 1<br>1                            | 1<br>1       | 1<br>1 | 1<br>1      | 1<br>1 | 1<br>1                              | 1<br>1              | R<br>R       | Midland, Coastal, Southern Coastlines   | Keep young by grazing or mowing. Named varieties must be grown from sprouts, only common bermudagrass can be seeded. |  |   |  |
| Bitterbrush  | 15<br>(33)                                   | 58.1<br>(65.1)        | 1<br>1            | 1<br>2            | 1<br>1            | 1<br>1                        | 1<br>1   | 3<br>1      | 1<br>1 | 1<br>1               | 1<br>1                            | 1<br>1       | 1<br>1 | 1<br>1      | 1<br>1 | 1<br>1                              | 1<br>1              | R<br>R       | Principal browse species used in range seedings.  | Palatable to all grazing species.  |  |   |  |
| Bluegrass, fine ( <i>Poa annua</i> )                 | 900<br>(1934)                                | 1.0<br>(1.1)          | 2<br>1-2          | 2<br>1            | 1<br>1            | 1<br>1                        | 1<br>1   | 1<br>1      | 1<br>1 | 2<br>2               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 2<br>2                              | 1<br>1              | R<br>R       | Seeds pulled up by many. Very early.  | Palatable to all grazing species.  |  |   |  |
| Bluegrass, Kentucky ( <i>Poa pratensis</i> )         | 130<br>(287)                                 | 6.7<br>(7.5)          | 2<br>1            | 2<br>2            | 1<br>1            | 2<br>2                        | 1<br>1   | 2<br>2      | 1<br>1 | 3<br>3               | 1<br>1                            | 3<br>3       | 1<br>1 | 3<br>3      | 1<br>1 | 3<br>3                              | 1<br>1              | R<br>R       | Very palatable and productive on dry sites.   | Good in warm, even moisture sites.   |  |   |  |
| Bluestem, big ( <i>Andropogon giganteus</i> )        | 860<br>(1886)                                | 1.0<br>(1.1)          | 2<br>1-2          | 2<br>2            | 1<br>1            | 2<br>2                        | 1<br>1   | 2<br>2      | 1<br>1 | 3<br>3               | 1<br>1                            | 3<br>3       | 1<br>1 | 3<br>3      | 1<br>1 | 3<br>3                              | 1<br>1              | R<br>R       | Lower in palatability than <i>P. glauca</i> , bluegrass but is more winter hardy. Seeds in pure stands generally. | Used in pastures, hay, and range.  |  |   |  |
| Bluestem, Caucasian ( <i>Andropogon caeruleus</i> )  | 265<br>(562)                                 | 3.4<br>(3.8)          | 2<br>1-2          | 1<br>1            | 3<br>1            | 1<br>1                        | 2<br>1   | 2<br>1      | 2<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 2<br>2                              | 1<br>1              | R<br>R       | Fast, tall, bluish.   | Widely used in warm season grass mixtures on mesic and subhumid sites.   |  |   |  |
| Bluestem, sand ( <i>Andropogon scoparius</i> )       | 113<br>(249)                                 | 7.7<br>(8.6)          | 2<br>1            | 2<br>1            | 3<br>1            | 2<br>1                        | 3<br>2   | 2<br>2      | 1<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 2<br>2                              | 1<br>1              | R<br>R       | Very palatable and productive on mesic sandy soils.   | Produced in pure stands, medium palatability.  |  |   |  |
| Bluestem, little ( <i>Andropogon furcatus</i> )      | 830<br>(1830)                                | 1.0<br>(1.1)          | 2<br>1            | 2<br>1            | 3<br>1            | 1<br>1                        | 2<br>1   | 2<br>1      | 2<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 2<br>2                              | 1<br>1              | R<br>R       | Fast, tall, bluish.   | Used in native grass mixtures in high mountain sites, used less now than formerly.                                   |  |   |  |
| Bluestem, Turk's cap ( <i>Andropogon scoparius</i> ) | 70<br>(154)                                  | 12.4<br>(13.9)        | 1<br>2            | 2<br>1            | 3<br>1            | 1<br>1                        | 2<br>1   | 3<br>1      | 1<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 2<br>2                              | 1<br>1              | R<br>R       | Fast, tall, bluish.   | Used in pastures, hay, and range.  |  |   |  |
| Brome, smooth ( <i>Bromus inermis</i> )              | 145<br>(320)                                 | 6.0<br>(6.7)          | 1<br>1            | 2<br>1            | 1<br>1            | 2<br>1                        | 1<br>1   | 2<br>1      | 1<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 3<br>3                              | 1<br>1              | R<br>R       | Tall, thin, Southland, Minnesota, Arkansas, Louisiana.  | Important irrigated pasture grass adapted to moist sites on gravel and sand.   |  |   |  |
| Buffalograss ( <i>Buchloe dactyloides</i> )          | 42<br>(93)                                   | 4.6<br>(4.6)          | 2<br>1            | 1<br>1            | 2<br>1            | 1<br>1                        | 1<br>1   | 2<br>1      | 2<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 3<br>3                              | 1<br>1              | R<br>R       | Very palatable.   | Low production. Seed only in mixtures. Sodded or transplanted by clumps or rhizomes.                                 |  |   |  |
| Burnet, small ( <i>Burnetia sanguinea</i> )          | 56<br>(121)                                  | 15.8<br>(17.7)        | 2<br>1            | 1<br>1            | 2<br>1            | 1<br>1                        | 2<br>1   | 1<br>1      | 2<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 3<br>3                              | 1<br>1              | R<br>R       | Fork with persistent leaves.  | Fork to prevent maturity. Pasture and hay on wet sites. Sodded or spread by end or culm cuttings.                    |  |   |  |
| Canarygrass, red ( <i>Phalaris canariensis</i> )     | 506<br>(1116)                                | 1.7<br>(1.9)          | 1<br>2            | 2<br>1            | 1<br>1            | 1<br>1                        | 1<br>1   | 2<br>1      | 1<br>1 | 3<br>3               | 1<br>1                            | 2<br>2       | 1<br>1 | 2<br>2      | 1<br>1 | 3<br>3                              | 1<br>1              | R<br>R       | Used, France, Highland, Australia.  | Paste to prevent maturity. Pasture and hay on wet sites. Sodded or spread by end or culm cuttings.                   |  |   |  |

Symbol 1 = cool, 2 = warm, 3 = hot

Symbol C = cool-season vs. warm-season

The rank and pasture regions are shown generally in figure 69.

Symbol R = rank and nonirrigated perennial pasture

I = irrigated and subirrigated pasture (Western half of United States only)

Seed weight information compiled from numerous printed sources.

Forage availability by season considers green growth period, palatability, cutting and seasonal grazing tolerance.

of four pure live burs per square foot

Wt. pure live seeds per square foot

Deviated seed

#PLS = pure live seeds or germinable units

Pounds PLS/A = pure live seeds/lb of pure seed

seeded units per lb of pure seed

| Common and scientific name   | Ratings of plant characteristics <sup>a</sup> |   |                           |                 |                               |        |            |            |                           |  | Regional adaptations <sup>b</sup> |   |              |  |
|--|---|---|---------------------------|-----------------|-------------------------------|--------|------------|------------|---------------------------|--|-----------------------------------|---|--------------|--|
|  | Seeds per lb (kg) x 1000 <sup>c</sup>         | Seeds/m <sup>2</sup> (kg/ha) PLSG for 20 <sup>d</sup> | Forage yield <sup>e</sup> | Soil adaptation | Forage usability <sup>f</sup> | Summer | Winter     | Principals | Principal named varieties | Special considerations and adaptations |                                   |   |              |  |
| Cliffrose<br>( <i>Cowania multiflora</i> )                             | 64<br>(141)                                   | 13.5<br>(1.4)   | 3<br>1                    | 1<br>1          | 2<br>2                        | 1<br>1 | 3<br>3     | 3<br>2     | 1<br>1                    | N                                      | R                                 | R |              |  |
| Clover, alpine<br>( <i>Trifolium pratense</i> )                        | 1880<br>(1439)                                | 1.3<br>(1.5)  | 2<br>3                    | 1<br>3          | 2<br>1                        | 1<br>1 | 1.2<br>2   | 1<br>2     | 1.2<br>1                  | R                                      | R                                 | I | R            |  |
| Clover, crimson<br>( <i>Trifolium incarnatum</i> )                     | 140<br>(609)                                  | 6.2<br>(7.0)  | 1<br>2                    | 3<br>1          | 2<br>1                        | 1<br>1 | 3<br>2     | 1<br>2     | 1<br>1                    | W                                      | R                                 | R | Dixie Auburn | Ta-Jukka   |
| Clover, Ladino white<br>( <i>Trifolium repens</i> )                    | 850<br>(1834)                                 | 1.0<br>(1.1)  | 1<br>2                    | 3<br>1          | 2.3<br>2                      | 1<br>1 | 2<br>2     | 1<br>1     | 2<br>1                    | R                                      | R                                 | I | R            | Merrit Pilgrim   |
| Clover, red<br>( <i>Trifolium pratense</i> )                           | 270<br>(595)                                  | 3.2<br>(3.6)  | 1<br>2                    | 3<br>1          | 3<br>2                        | 1<br>1 | 2<br>2     | 1<br>1     | 2<br>2                    | 1.2<br>1                               | R                                 | R | I            | R  |
| Clover, rose<br>( <i>Trifolium pratense</i> )                          | 140<br>(609)                                  | 6.2<br>(7.0)  | 1<br>2                    | 3<br>1          | 2<br>2                        | 1<br>1 | 3<br>2     | 1<br>1     | 2<br>2                    | 1<br>1                                 | R                                 | R | R            | Mammoth, Doolard, Midland, Lakeland, Kentland, Penncross   |
| Clover, strawberry<br>( <i>Trifolium fragiferum</i> )                  | 295<br>(650)                                  | 3.0<br>(3.4)  | 1<br>1.2                  | 3<br>2          | 1.2<br>1.2                    | 2<br>2 | 1<br>1     | 1<br>1     | 2<br>2                    | 1<br>1                                 | R                                 | R | R            | Tallgrass Mt., Barker, Marcella  |
| Clover, subterranean<br>( <i>Trifolium subterraneum</i> )              | 65<br>(143)                                   | 13.4<br>(16.0)  | 2<br>2                    | 2<br>3          | 3<br>2                        | 1<br>1 | 2<br>2     | 1<br>1     | 2<br>2                    | 1<br>1                                 | R                                 | R | R            | Winter annual  |
| Dallisgrass<br>( <i>Paspalum dilatatum</i> )                           | 220<br>(485)                                  | 4.0<br>(4.5)  | 2<br>1.2                  | 2<br>2          | 2<br>2                        | 1<br>1 | 1<br>1     | 2<br>2     | 1<br>1                    | 2<br>2                                 | R                                 | R | I            | Long grazing period in Southwest   |
| Dropped seed<br>( <i>Spergularia villosa</i> )                         | 5000<br>(11023)                               | .47<br>(.3)   | 1<br>2                    | 1<br>1          | 2<br>1                        | 1<br>1 | 2<br>2     | 2<br>2     | 2<br>2                    | 3<br>3                                 | R                                 | R | R            | Seeded on dry sites where winter forage is adapted   |
| Fescue, hard<br>( <i>Festuca rubra</i><br>var. <i>durietzii</i> )      | 565<br>(1246)                                 | 1.5<br>(1.7)  | 2<br>1                    | 2<br>1          | 3<br>2                        | 1<br>1 | 3<br>2     | 2<br>2     | 3<br>2                    | 1<br>1                                 | R                                 | R | R            | Used mostly in erosion control generally palatable robust form   |
| Fescue, Idaho<br>( <i>Festuca idahoensis</i> )                         | 450<br>(992)                                  | 1.9<br>(2.1)  | 1<br>1                    | 2<br>1          | 1<br>1                        | 2<br>1 | 3<br>2     | 1<br>1     | 2<br>2                    | 2<br>2                                 | R                                 | R | R            | Lack of windbreaks restricts its use   |
| Fescue, tall<br>( <i>Festuca arundinacea</i> )                         | 227<br>(500)                                  | 3.8<br>(4.3)  | 1<br>1                    | 2.3<br>2.3      | 1<br>1                        | 1<br>1 | 2<br>2     | 1<br>1     | 2<br>2                    | 2<br>2                                 | R                                 | R | R            | Generally seeded in pure stands occasionally in irrigated pasture mixes. Winter killed in South        |
| Foxtail, meadow<br>( <i>Alopecurus pratensis</i> )                     | 580<br>(1279)                                 | 1.5<br>(1.7)  | 1<br>1                    | 2.3<br>2.3      | 1<br>1                        | 1<br>1 | 2<br>2     | 1<br>1     | 2<br>2                    | 1<br>1                                 | R                                 | R | I            | Cerropac frost (A. arundinaceus) and meadows are well adapted to mountain meadows. Slightly thiaminous |
| Grama, black<br>( <i>Bouteloua eriopoda</i> )                          | 1335<br>(2943)                                | .7<br>(.8)  | 2.3<br>2                  | 1<br>1          | 3<br>2                        | 1<br>1 | 3<br>2     | 1<br>1     | 2<br>2                    | N                                      | R                                 | R | R            | Good quality seed is scarce  |
| Grama, blue<br>( <i>Bouteloua gracilis</i> )                           | 711<br>(1567)                                 | 1.2<br>(1.4)  | 2<br>1                    | 1<br>1          | 2<br>1                        | 1<br>1 | 3<br>2     | 1<br>1     | 2<br>2                    | N                                      | R                                 | R | R            | Captain Maria, Lowdown   |
| Grama, blodock<br>( <i>Bouteloua curtipendula</i> )                    | 191<br>(422)                                  | 4.6<br>(5.2)  | 1<br>1                    | 1.2<br>1.2      | 1<br>1                        | 2<br>2 | 2<br>2     | 1<br>1     | 2<br>2                    | 1<br>1                                 | R                                 | R | R            | Premier Butte, Ida Way, Corralito, Keno, Tawap, Vaughan, Leslie, Terra                                 |
| Hardinggrass<br>( <i>Phalaris tuberosa</i><br>var. <i>strobifera</i> ) | 350<br>(772)                                  | 2.5<br>(2.8)  | 1<br>1                    | 2<br>2          | 2<br>2                        | 1<br>1 | 2<br>2     | 1<br>1     | 2<br>2                    | 1<br>1                                 | R                                 | I | R            | IAN, Wintergreen   |
| Indiangrass<br>( <i>Sorghastrum nutans</i> )                           | 170<br>(378)                                  | 5.1<br>(5.7)  | 2<br>1                    | 3<br>1          | 1<br>1                        | 2<br>1 | 1.2<br>1.2 | 3<br>3     | 1<br>1                    | 2<br>2                                 | N                                 | R | R            | Hill, Neph, Cheyenne, Laramie, Tex.  |
| Johnsongrass<br>( <i>Sorghum halepense</i> )                           | 118<br>(260)                                  | .4<br>(.8)  | 1<br>1                    | 1.2<br>1.2      | 2<br>2                        | 1<br>1 | 1<br>1     | 2<br>2     | 1<br>1                    | 2<br>2                                 | N                                 | K | R            | Kultivations, prevent from spreading to cultivated lands. HC potential very palatable and productive   |

| Common and scientific name   | Ratings of plant characteristics <sup>a</sup> |                |                               |       |                               |                      |                            |            |  |                       | Regional adaptations |                  |     |   |   |
|--|---|----------------|-------------------------------|-------|-------------------------------|----------------------|----------------------------|------------|--|-----------------------|----------------------|------------------|-----|---|---|
|  | Soil adaptation                               |                | Forage usability <sup>b</sup> |       | Cattle tolerance <sup>c</sup> |                      | Principled named varieties |            | Special considerations and adaptations |                       |                      |                  |     |   |   |
|  | Sand  | Silt           | Fine                          | Summa | Early sprout                  | High water tolerance | Cold hardiness             | Sturdiness | Seeds per lb (kg) x 1000 <sup>d</sup>  | Season of germination | Period of dormancy   | Winter hardiness |     |   |   |
| Klinggrass, <i>Leymus</i> <i>triticoides</i>   | 497<br>(1086)                                 | 1.8<br>(2.0)   | 1                             | 2     | 1                             | 2                    | 1                          | 1          | 1                                      | W                     | R                    | R                |     |   |   |
| Lovergrass, <i>Buerger</i> <i>litoralis</i> <i>litoralis</i>                           | 2922<br>(6442)                                | 6.7<br>(7.7)   | 2                             | 1     | 2                             | 1                    | 1                          | 1          | 1                                      | N                     | K                    |                  |     |   |   |
| Lovergrass, Lehmann <i>litoralis</i> <i>lehmanna</i>                                   | 4246<br>(8359)                                | 4.7<br>(5.0)   | 1                             | 1     | 1                             | 1                    | 1                          | 1          | 1                                      | N                     | K                    |                  |     |   |   |
| Lovergrass, sand <i>Eragrostis</i> <i>saccata</i> <i>saccata</i>                       | 1300<br>(2668)                                | .7<br>(.8)     | 2                             | 1     | 1.2                           | 1                    | 1                          | 1          | 1                                      | N                     | R                    | R                |     |   |   |
| Lovergrass, weeping <i>Eragrostis</i> <i>curvula</i> <i>curvula</i>                    | 1360<br>(3307)                                | .6<br>(.7)     | 2                             | 1.2   | 2                             | 1                    | 1                          | 1          | 1                                      | W                     | R                    | R                |     |   |   |
| Milkvetch, <i>Alcea</i> <i>strumosa</i> <i>strumosa</i>                                | 146<br>(320)                                  | 6.0<br>(6.7)   | 2                             | 2     | 2                             | 1                    | 1                          | 2          | 1                                      | 1                     | N                    | R                |     |   |   |
| Mountain mahogany, curlleaf <i>Chrysothamnus</i> <i>curlifolius</i> <i>curlifolius</i> | 52<br>(115)                                   | 16.7<br>(18.7) | 2                             | 1     | 1                             | 2                    | 1                          | 1          | 2                                      | 2                     | 1                    | 1                | 1.2 | N | R |
| Mountain mahogany, true <i>Chrysothamnus</i> <i>moniliflorus</i> <i>moniliflorus</i>   | 59<br>(130)                                   | 14.8<br>(16.6) | 1                             | 2     | 1                             | 2                    | 1                          | 1          | 2                                      | 1                     | 1                    | 1                | 1.2 | N | R |
| Needlegrass, green <i>Stipa</i> <i>viridis</i> <i>viridis</i>                          | 181<br>(398)                                  | 4.8<br>(5.4)   | 2                             | 1     | 1                             | 1                    | 1                          | 1          | 1                                      | 1                     | 2                    | N                |     |   |   |
| Needlegrass, tall <i>Arhenatherum</i> <i>eragrostis</i> <i>eragrostis</i>              | 150<br>(331)                                  | 5.8<br>(6.5)   | 1                             | 2     | 2                             | 1                    | 1                          | 1          | 2                                      | 1                     | 1                    | N                |     |   |   |
| Orchardgrass, <i>Dactylis</i> <i>glomerata</i> <i>glomerata</i>                        | 540<br>(1191)                                 | 1.6<br>(1.8)   | 1                             | 2     | 2.3                           | 2                    | 1                          | 1          | 2                                      | 1                     | 1                    | R                | R   |   |   |
| Pangolagrass <i>Dactyloctenium</i> <i>zizanioides</i> <i>zizanioides</i>               | 1   | 2              | 3                             | 1     | 1                             | 1                    | 1                          | 1          | 1                                      | 1                     | 1                    | N                | R   |   |   |
| Panicgrass, blue <i>Pennisetum</i> <i>caeruleum</i> <i>caeruleum</i>                   | 857<br>(1448)                                 | 1.3<br>(1.5)   | 1                             | 2     | 1.2                           | 2                    | 1                          | 1          | 2                                      | 1                     | 1                    | R                | R   |   |   |
| Redtop <i>Aristida</i> <i>erecta</i> <i>erecta</i>                                     | 4990<br>(11001)                               | 4.7<br>(4.5)   | 2                             | 1     | 3                             | 1                    | 1                          | 1          | 2                                      | 3                     | 1                    | C                | 1   | 1 |   |
| Rhodesgrass, <i>Chondrus</i> <i>cavendishii</i>  | 2143<br>(4725)                                | .81<br>(.9)    | 2                             | 3     | 1                             | 2                    | 1                          | 1          | 2                                      | 2                     | 1                    | R                | R   |   |   |
| Ricegrass, India, <i>Oryzopsis</i> <i>indica</i> <i>indica</i>                         | 188<br>(414)                                  | 4.6<br>(6.2)   | 1                             | 1     | 1                             | 1                    | 1                          | 1          | 2                                      | 1                     | 1                    | R                | R   |   |   |
| Sacaton, allah <i>Sporobolus</i> <i>atropurpureus</i> <i>atropurpureus</i>             | 1750<br>(3886)                                | 1.07<br>(1.1)  | 2                             | 1     | 1                             | 1                    | 1                          | 1          | 1                                      | 2                     | 1                    | N                | R   | R |   |
| Sagebrush, big <i>Atriplex</i> <i>polystachys</i> <i>polystachys</i>                   | 2576<br>(5679)                                | .3<br>(.3)     | 1                             | 1     | 1                             | 1                    | 1                          | 1          | 1                                      | 3                     | 2                    | 1                | N   | R | R |

| Common and scientific name  | Ratings of plant characteristics <sup>3</sup> |                               |        |            |              |                      |                    |                 |                   |                    | Principally named varieties | Special considerations and adaptations |  |
|---|---|-------------------------------|--------|------------|--------------|----------------------|--------------------|-----------------|-------------------|--------------------|-----------------------------|--|--|
|   | Regional adaptation <sup>2</sup>              |                               |        |            |              | Seasonal performance |                    |                 |                   |                    |                             |  |  |
|   | Soil adaptation                               | Forage usability <sup>3</sup> | Winter | Summer     | Early spring | High water tolerance | Stands maintenance | Child hardiness | Drought tolerance | Salinity tolerance | Silvics                     | Climate                                |  |
| Salibach four-wind<br>( <i>Aristea ecklonii</i> )                   | 708<br>(154)                                  | 2<br>1                        | 1<br>1 | 1<br>1     | 1<br>1       | 2<br>2               | 2<br>1             | 1<br>1          | 1<br>1            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Sandreed prairie<br>flamegrass ( <i>Eragrostis lehmanniana</i> )    | 274<br>(604)                                  | 3.2<br>2                      | 1<br>1 | 1<br>1     | 1<br>1       | 2<br>2               | 1<br>1             | 1<br>1          | 1<br>1            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Servalberry<br>( <i>Acanthocarpus ilicoides</i> )                   | 45<br>(99)                                    | 19.4<br>2                     | 2<br>1 | 1<br>3     | 1<br>1       | 1<br>1               | 1<br>1             | 2<br>2          | 2<br>2            | N<br>N             | R<br>R                      | R<br>R                                 |  |
| Sinaloagras<br>( <i>Acetosella sinaloensis</i> )                    | 388<br>(1949)                                 | 1.0<br>2                      | 1<br>1 | 1<br>1     | 1<br>1       | 2<br>2               | 1<br>1             | 2<br>2          | 2<br>2            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Sweetclover, white<br>( <i>Melilotus albus</i> )                    | 260<br>(573)                                  | 3.4<br>1.2                    | 1<br>1 | 1<br>1     | 1<br>1       | 2<br>2               | 1<br>1             | 2<br>2          | 2<br>2            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Sweetclover yellow<br>( <i>Melilotus officinalis</i> )              | 260<br>(573)                                  | 3.4<br>1.2                    | 1<br>1 | 1<br>1     | 1<br>1       | 2<br>2               | 1<br>1             | 2<br>2          | 2<br>2            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Switchgrass<br>green grass<br>( <i>Pennisetum setosum</i> )         | 389<br>(658)                                  | 2.2<br>1.2                    | 1<br>1 | 2<br>1     | 1<br>1       | 1<br>1               | 1<br>1             | 3<br>3          | 3<br>3            | 2<br>2             | N<br>N                      | R<br>R                                 |  |
| Timothy<br>( <i>Phleum pratense</i> )                               | 1230<br>(2712)                                | .7<br>1.2                     | 1<br>1 | 1<br>1     | 1<br>1       | 2<br>2               | 1<br>1             | 1<br>1          | 1<br>1            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Trefoil, birdfoot<br>( <i>Lotus corniculatus</i> )                  | 407<br>(897)                                  | 2.1<br>2.4                    | 3<br>2 | 1<br>2     | 1<br>1       | 1<br>1               | 1<br>1             | 2<br>2          | 2<br>2            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Vine mesquite<br>( <i>Jamacia hispida</i> )                         | 143<br>(313)                                  | 6.1<br>6.8                    | 2<br>2 | 2<br>2     | 1<br>1       | 1<br>1               | 1<br>1             | 2<br>2          | 2<br>2            | 1<br>1             | N<br>N                      | R<br>R                                 |  |
| Wheatgrass, banded<br>( <i>Aegopodium podagraria</i> )              | 142<br>(313)                                  | 6.1<br>6.8                    | 2<br>1 | 1<br>1     | 2<br>2       | 1<br>1               | 3<br>2             | 1<br>1          | 1<br>1            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Wheatgrass, bluebeard<br>( <i>Aegopodium spicatum</i> )             | 117<br>(258)                                  | 7.4<br>8.3                    | 2<br>2 | 1<br>1     | 2<br>1       | 1<br>1               | 1<br>1             | 2<br>1          | 1<br>1            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Wheatgrass, crested<br>fairyway<br>( <i>Aegopodium cretaceum</i> )  | 200<br>(441)                                  | 4.4<br>4.9                    | 1<br>1 | 1<br>1     | 2<br>1       | 1<br>1               | 2<br>1             | 1<br>1          | 1<br>1            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Wheatgrass, intermediate<br>( <i>Aegopodium intermedium</i> )       | 93<br>(205)                                   | 9.4<br>(0.05)                 | 1<br>1 | 1.2<br>2   | 1.2<br>2     | 3<br>3               | 1<br>1             | 2<br>2          | 1<br>1            | 2<br>2             | R<br>R                      | R<br>R                                 |  |
| Wheatgrass, palecent<br>( <i>Aegopodium pilosum</i> )               | 90<br>(138)                                   | 9.7<br>(10.9)                 | 1<br>1 | 1<br>1     | 2<br>1       | 1<br>1               | 2<br>1             | 1<br>1          | 2<br>1            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Wheatgrass, Siberian<br>( <i>Aegopodium sibiricum</i> )             | 206<br>(454)                                  | 4.2<br>4.7                    | 1<br>1 | 1<br>1     | 2<br>2       | 1<br>1               | 2<br>1             | 1<br>1          | 3<br>2            | 1<br>1             | R<br>R                      | R<br>R                                 |  |
| Wheatgrass, slender<br>( <i>Aegopodium paniculatum</i> )            | 160<br>(333)                                  | 5.4<br>6.1                    | 1<br>1 | 2<br>2     | 1<br>1       | 2<br>2               | 1<br>1             | 2<br>2          | 1<br>1            | 2<br>2             | R<br>R                      | R<br>R                                 |  |
| Wheatgrass, standard<br>crested<br>( <i>Aegopodium desertorum</i> ) | 175<br>(386)                                  | 5.0<br>5.6                    | 1<br>1 | 1<br>1     | 2<br>2       | 1<br>1               | 2.3<br>1           | 1<br>1          | 2<br>1            | 1<br>1             | C<br>C                      | R<br>R                                 |  |
| Wheatgrass, tall<br>( <i>Aegopodium elongatum</i> )                 | 79<br>(174)                                   | 11.0<br>(12.3)                | 1<br>1 | 1<br>1     | 1<br>1       | 1<br>1               | 1<br>1             | 1<br>1          | 1<br>1            | 1<br>1             | C<br>C                      | R<br>R                                 |  |
| Whanggrass, western<br>( <i>Aegopodium smithii</i> )                | 126<br>(278)                                  | 8.9<br>7.7                    | 2<br>1 | 1<br>1     | 1<br>1       | 1<br>1               | 1<br>1             | 1<br>1          | 1<br>1            | 1<br>1             | N<br>N                      | C<br>C                                 |  |
| Wildrye, basin or giant<br>( <i>Elymus caninus</i> )                | 95<br>(209)                                   | 9.2<br>(10.3)                 | 2<br>1 | 2.3<br>2.3 | 1<br>1       | 1.2<br>1.2           | 3<br>3             | 1<br>1          | 1.2<br>1.2        | 2<br>2             | N<br>N                      | N<br>N                                 |  |

| Common and scientific name  | Ratings of plant characteristics <sup>a</sup> |                               |                                   |        |      |                           |           |              |           |  | Special considerations and adaptations |           |           |
|---|---|-------------------------------|-----------------------------------|--------|------|---------------------------|-----------|--------------|-----------|--|--|-----------|-----------|
|   | Soil adaptation                               | Forage usability <sup>b</sup> | Regional adaptations <sup>c</sup> |        |      | Principal named varieties |           |              |           | Special considerations and adaptations |  |           |           |
| Season of growth <sup>d</sup>   | Native or introduced                          | Winter                        | Spring                            | Summer | Fall | Midwest                   | Southwest | Great Plains | Northwest | Pacific Coast                          | Intermountain                          | Southeast | Northeast |
| Wildrye, Canada<br>( <i>Elymus canadensis</i> )                                     | 7.06<br>(234)                                 | 8.2<br>(9.2)                  | 2                                 | 1      | 2    | 1                         | 1         | 2            | 3         | 2                                      | N                                      | C         | R         |
| Wildrye, Renselan<br>( <i>Elymus junceus</i> )                                      | 1.75<br>(3.86)                                | 5.0<br>(5.6)                  | 1                                 | 1      | 1    | 3                         | 1         | 1            | 2         | 1                                      | -                                      | C         | R         |
| Winter rye<br>( <i>Erythraea lanata</i> )   | 55<br>(121)                                   | 15.8<br>(17.7)                | 2                                 | 1      | 1    | 1                         | 1         | 3            | 2         | 1                                      | 1                                      | 1         | R         |
| Lb./acre (kg./ha) PLS <sup>e</sup> for 20 seeds/sq ft (215 seeds/m <sup>2</sup> )   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Seeds per lb (kg) x 1000 <sup>f</sup>   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Saltinity tolerance <sup>g</sup>  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Cold hardiness <sup>h</sup>   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Drought tolerance <sup>i</sup>  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Stem and rhizome tolerance <sup>j</sup>   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Frost of establishment <sup>k</sup>   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Sandiness <sup>l</sup>  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Clayey <sup>m</sup>   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Summer  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Late spring   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Early spring  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Fall  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Winter  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Grazing tolerance <sup>n</sup>  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Native or introduced  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Season of growth <sup>d</sup>   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| N   |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Vinal, Sawki  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Mandan  |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Lack of stand maintenance and tolerance of grazing has limited its use.             |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Seed alone or with alfalfa. Early growth. Very hardy once established.              |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |
| Superior palatability, productivity, and adaptability; tolerates grass competition. |   |                               |                                   |        |      |                           |           |              |           |  |  |           |           |

Vallentine, J. F. 1971. Range development and improvements. Brigham Young University: Press, Provo, Utah. 516 p.

# Appendix E

## Metric Conversions

### *Measures of length:*

1 inch = 2.54 centimeters = 25.40 millimeters  
1 foot = .3048 meters = 30.48 centimeters  
1 yard = .9144 meters = 91.44 centimeters  
1 mile = 1.609 kilometers = 1,609 meters  
1 nautical mile = 1.152 miles = 1.853 kilometers

### *Measures of surface:*

1 square inch = 6.452 square centimeters  
1 square foot = .0929 square meters  
1 square yard = .8361 square meters  
1 acre = .4047 hectares = 4,047 square meters  
1 square mile = 259 hectares = 2.590 square kilometers

### *Measures of volume:*

1 cubic inch = 16.39 cubic centimeters = 16.39 milliliters  
1 cubic foot = .02832 cubic meters = 28.32 liters  
1 cubic yard = .7646 cubic meters = .7646 kiloliters  
1 quart = .9464 liters  
1 U. S. gallon = 3.785 liters  
1 bushel = 1.245 cubic feet = 35.24 liters

### *Measures of weight:*

1 ounce = 28.35 grams  
1 pound = .4536 kilograms = 453.6 grams  
1 ton = 907.2 kilograms = .9072 metric tons

### *Measure of pressure:*

1 pound per square inch (PSI) = 6.895 kiloPascals

### *Measure of power:*

1 horsepower = .7457 kiloWatts

### *Measure of temperature:*

$X^{\circ}$  Farenheit =  $(X-32)5/9^{\circ}$  Celsius  
Change of  $1^{\circ}$  Farenheit = change of  $.5556^{\circ}$  Celsius











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